INSIDE GM'S SATURN: A NEW WAY TO BUILD CARS

CLEAN-AIR PAINTS • SATELLITE CATAPULT

Popular Science

Computers without keyboards

Car test: the latest minivans

SUN RACERS

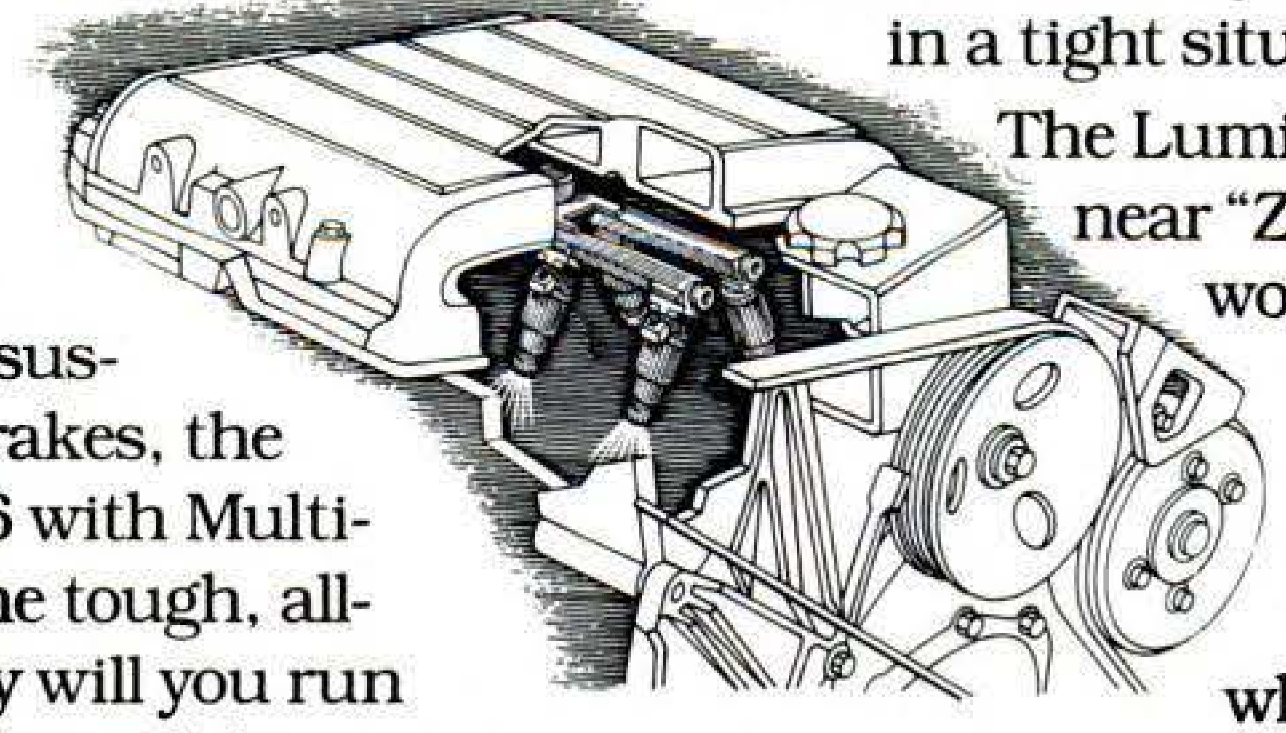
AUGUST 1990
$2.00
CANADA $2.50

Lumina Sedan. It's designed to steer clear of trouble.

Granted, most of us will never need to understand the science behind near Zero Scrub Radii, drag coefficients, heat dissipation in braking, or, for that matter, modern day algebra. But everyone can understand the benefits of a car designed to help them respond to trouble on the road.

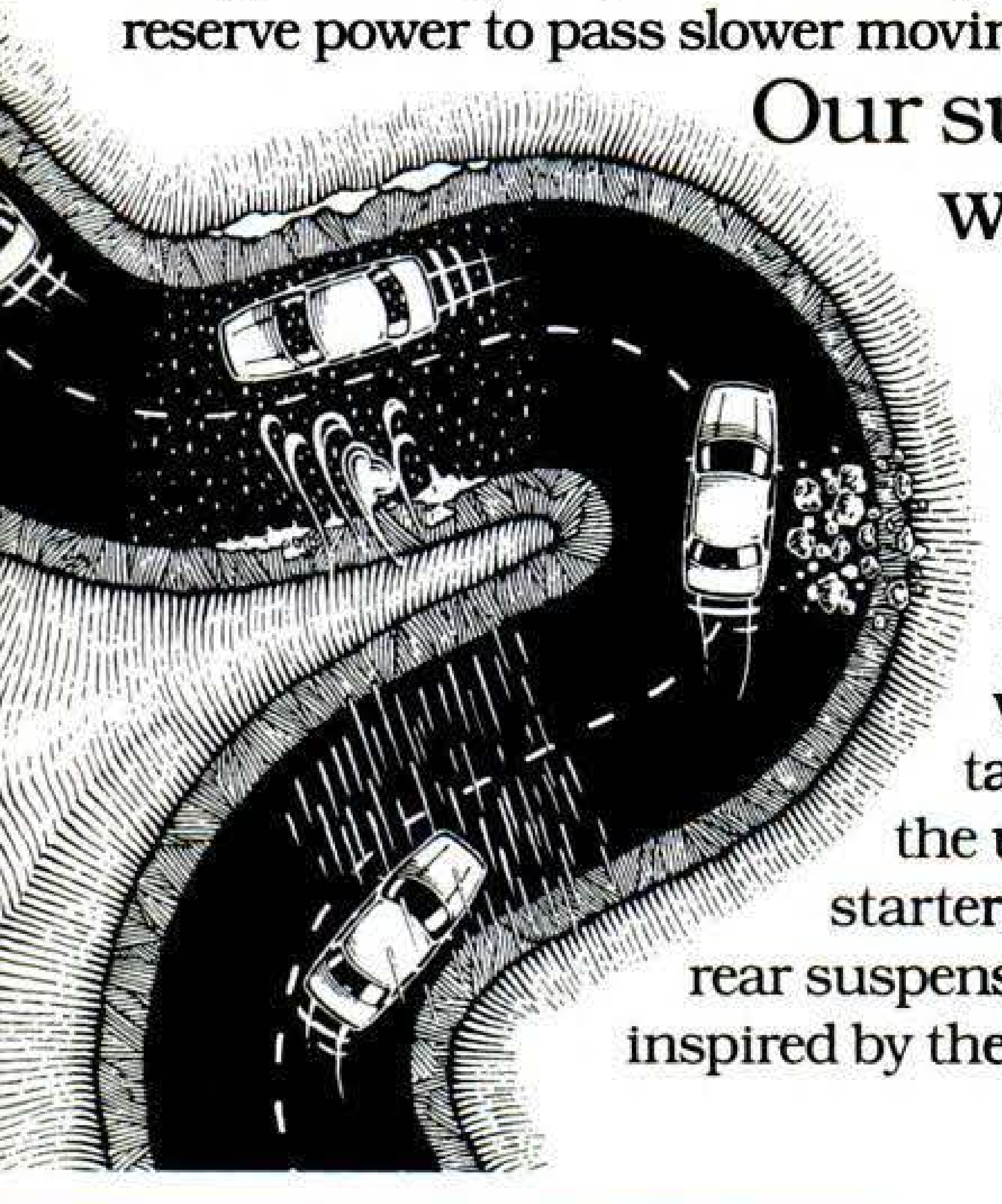
So, we'd like to explain in some detail some very technical reasons why you should choose the Lumina Sedan to be your next family car. Because when you put all those benefits together, they help make the Lumina Sedan one of the most innovative and responsive Chevrolet automobiles ever.

The engineering that went into the engine.



Can you see the safety aspects of an engine? Our engineers can. By taking into account the weight of the car, suspension geometry, tires and brakes, the Lumina's available 3.1 Liter V6 with Multi-Port Fuel Injection becomes one tough, all-around performer. So, not only will you run your family around the city efficiently,* you can merge into highway traffic swiftly and have enough reserve power to pass slower moving vehicles.

Our suspension won't keep you in suspense.



You'll appreciate Lumina's suspension most when the road takes a turn for the unexpected. For starters, the Lumina's rear suspension design was inspired by the Corvette. Its leaf spring is made of fiberglass, not steel. And instead of one steel spring per wheel, as in many cars, one fiberglass rear leaf spring is all that's needed in the Lumina. And with its advanced suspension, your Lumina is designed to help you recover quickly should you have to swerve to avoid something in the road.

Here's how. In a swerve, when you turn the wheel hard to the left, the right side of your car will push down. Straighten the wheel, and as the right side comes up, the left side will go down. This is called roll. But thanks to the tuning of Lumina's fiberglass rear leaf spring suspension, you'll experience less roll, so your car will respond more quickly in a tight situation.

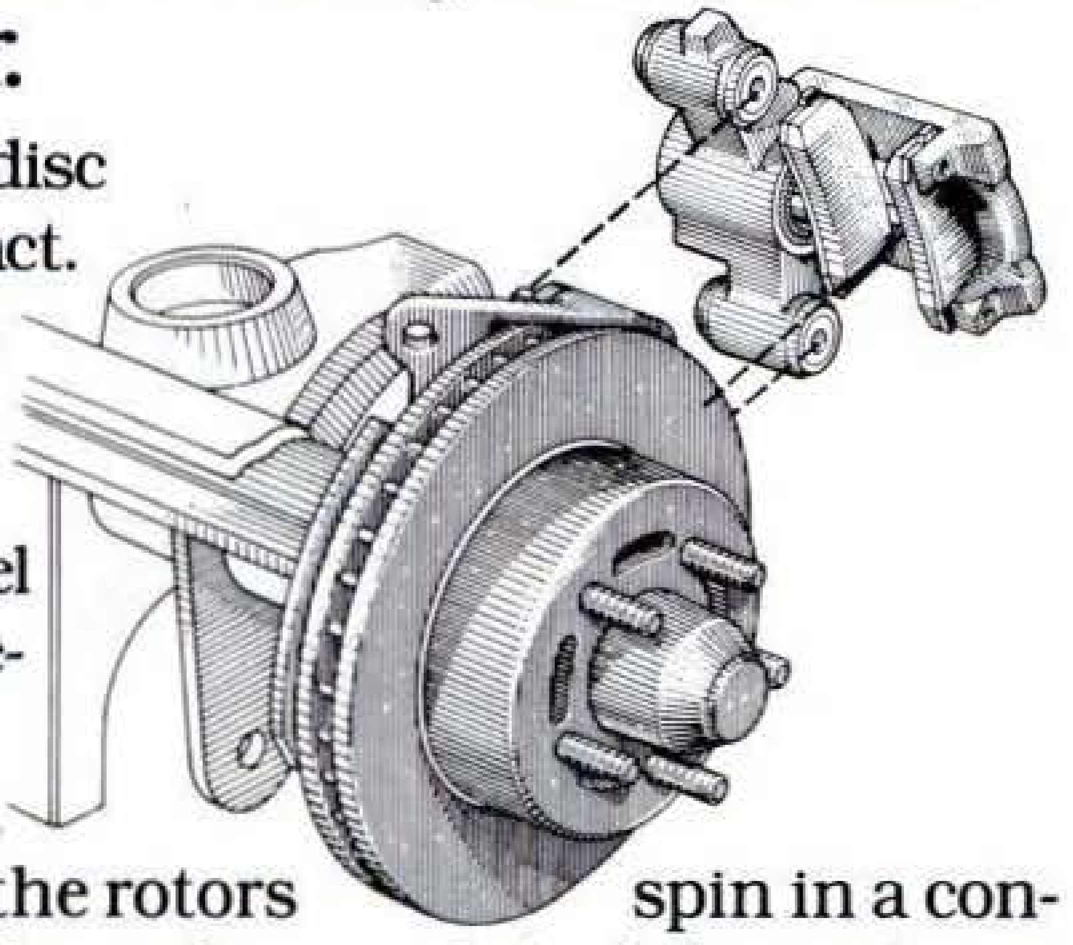
The Lumina's front suspension also boasts near "Zero Scrub Radii." Unfortunately, it would take pages to explain it. So suffice it to say that in some cars when you drive through a puddle at 35 miles an hour your car will slow down and your steering wheel will pull. To lessen this, the Lumina was designed with near Zero Scrub Radii which reduces the sensitivity of your front wheels to changes in the road to help you stay in control without having to overcompensate at the steering wheel. A very helpful feature.

We'd like to clear the air about aerodynamics.

Admittedly, the technical aspects of aerodynamics, such as crosswind stability and drag coefficients, are less than thrilling. We'd much rather describe for you how the Lumina's aerodynamics can contribute to your safety. For instance, Lumina's smooth shape allows for a low drag coefficient of 0.34 which contributes to impressive fuel economy* and acceleration when passing or merging. But those aren't the only rewards of smooth aerodynamics.

Believe it or not, the Lumina is not only aerodynamic when the wind is rushing over the front end, it's aerodynamic when the wind is coming at you from the side. And you'll appreciate that on very windy days or when you get caught in the wake of a passing semi on the interstate.

Here's the brake you've been looking for.

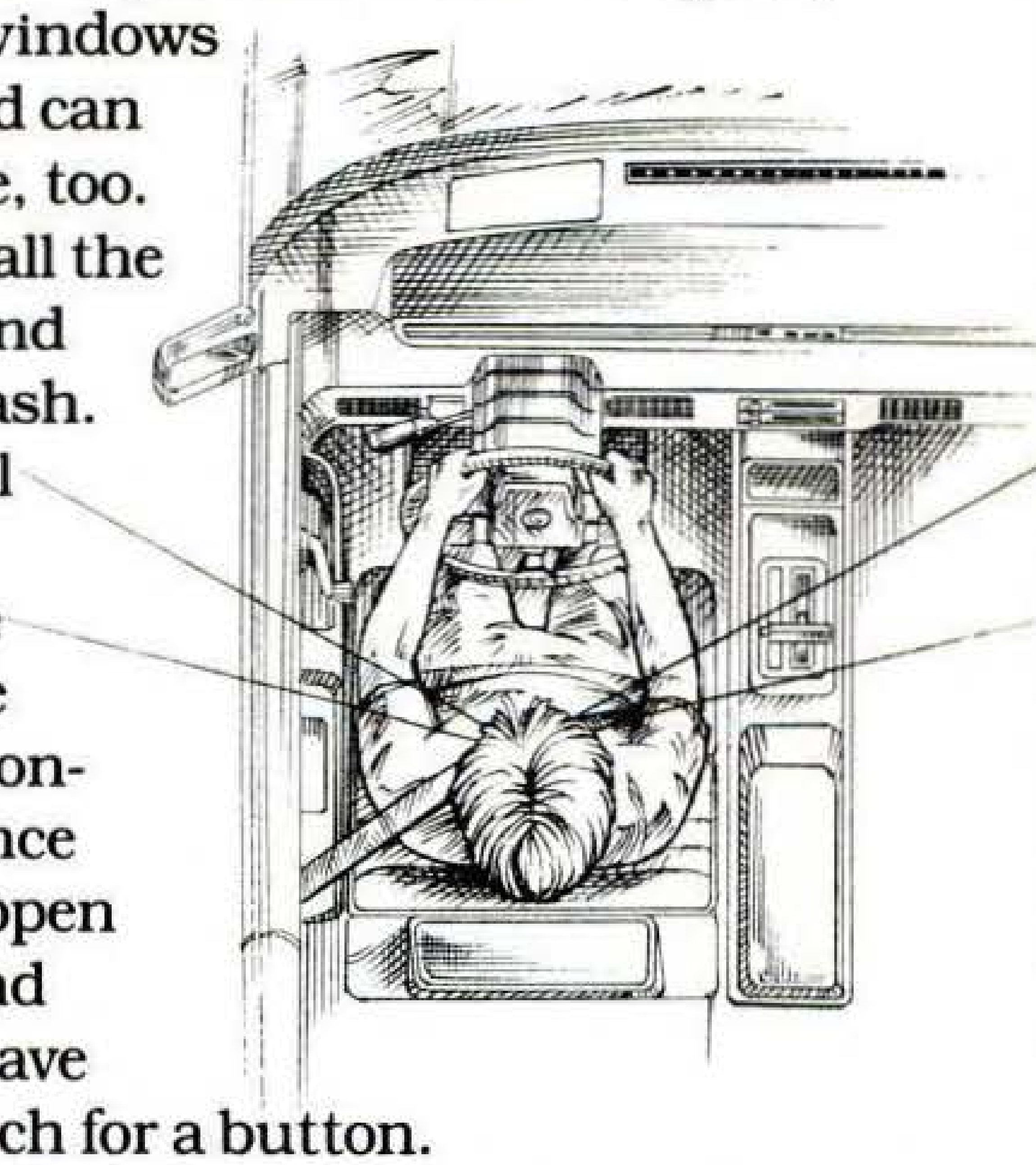


Four-wheel disc brakes, to be exact. They come standard on the Lumina Sedan. Lumina's 4-wheel disc brakes benefit from greater heat dissipation. That's because the rotors spin in a constant air flow to keep them cool. And the cooler the brakes stay, the more efficiently they work. Now you could buy a Ford Taurus and not get these standard. Or you can buy a Lumina and get standard 4-wheel disc brakes. The choice is yours.

Know what you're getting into.

Innovation isn't limited to exterior features of the Lumina Sedan. Here are just two examples of some thoughtful interior design that may not be evident at first glance.

Notice all the glass. The windows seem deep and wide, don't they? While providing a very comfortable feeling of expansiveness, this also serves a very practical function: better visibility. And while all that glass helps eliminate blind spots, standard tinted windows all the way around can cut down on glare, too.



Next, look at all the buttons, knobs and controls on the dash. Notice how logical their placement, how easy they are to reach. A simple thing, true, but consider its importance and what can happen in that split second when your eyes leave the road and search for a button.

Now we hope we didn't bore you with all these explanations, but we thought the more you knew about the Lumina Sedan before getting into it, the more you and your family would be able to get out of it.

To find out even more, come in and test drive a Lumina for yourself or, better yet, ask a friend who's driving one. Either way, you're sure to see why Lumina is the fastest-selling 1990 new car name. And why more Americans are winning with The Heartbeat of America.

THE Heartbeat
OF AMERICA IS WINNING.
TODAY'S CHEVROLET ™

*EPA estimated MPG city 19/highway 27. Chevrolet, the Chevrolet emblem, Lumina and Corvette are registered trademarks of the GM Corp. ©1990 GM Corp. All Rights Reserved. Let's get it together... buckle up. GM®

WE MAKE EARNING MONEY FOR COLLEGE AN EDUCATION IN ITSELF.

How does earning over $18,000 for college sound? That's what you can get if you qualify for the Montgomery GI Bill and add that to your pay during a standard enlistment in the Army Reserve.

You can get help in paying off some or all of a qualified student loan, too, through the Student Loan Repayment Program. And, while you're getting help with college costs, you'll get a chance to train in a useful skill.

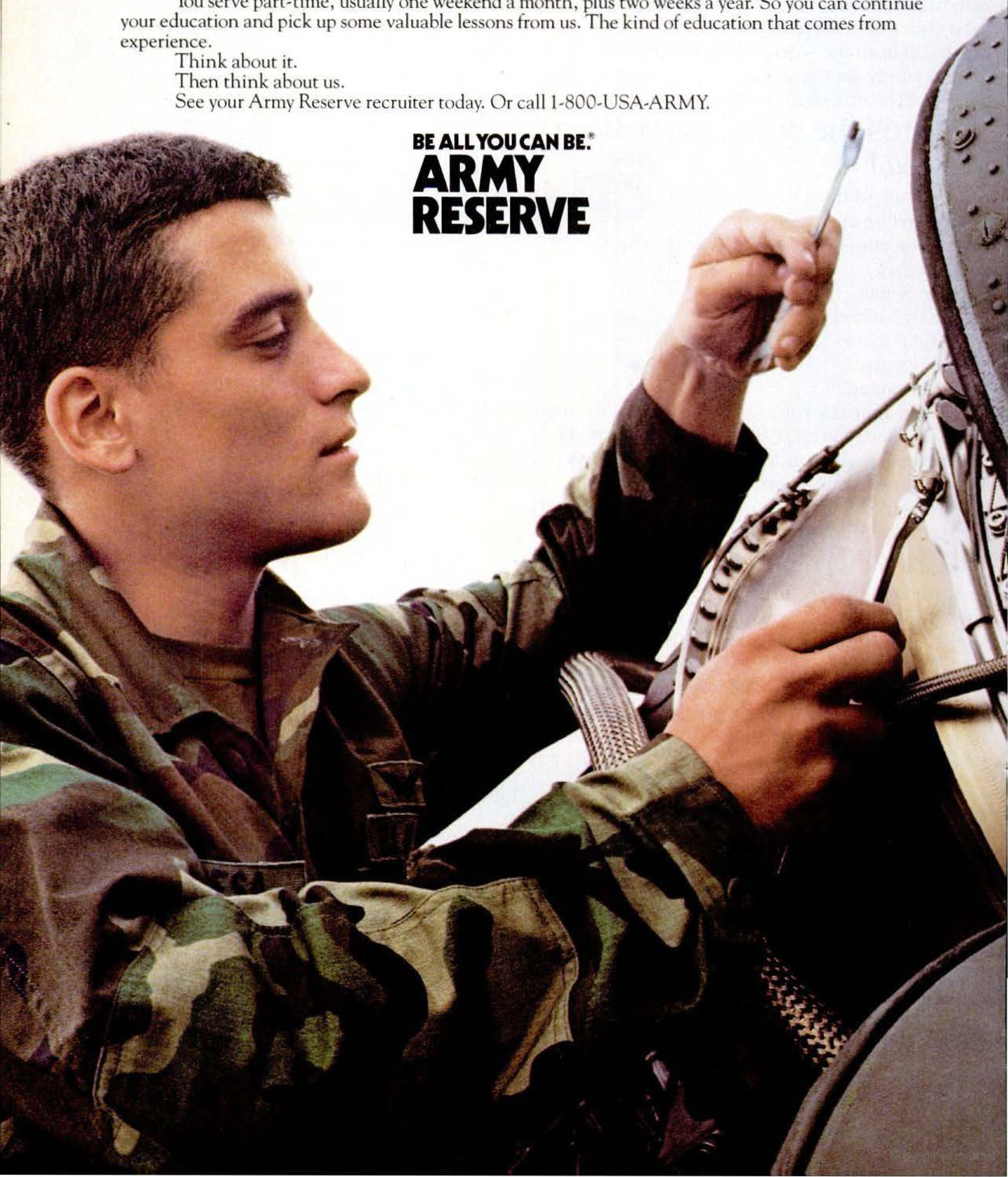
You serve part-time, usually one weekend a month, plus two weeks a year. So you can continue your education and pick up some valuable lessons from us. The kind of education that comes from experience.

Think about it.

Then think about us.

See your Army Reserve recruiter today. Or call 1-800-USA-ARMY.

BE ALL YOU CAN BE.®
ARMY
RESERVE



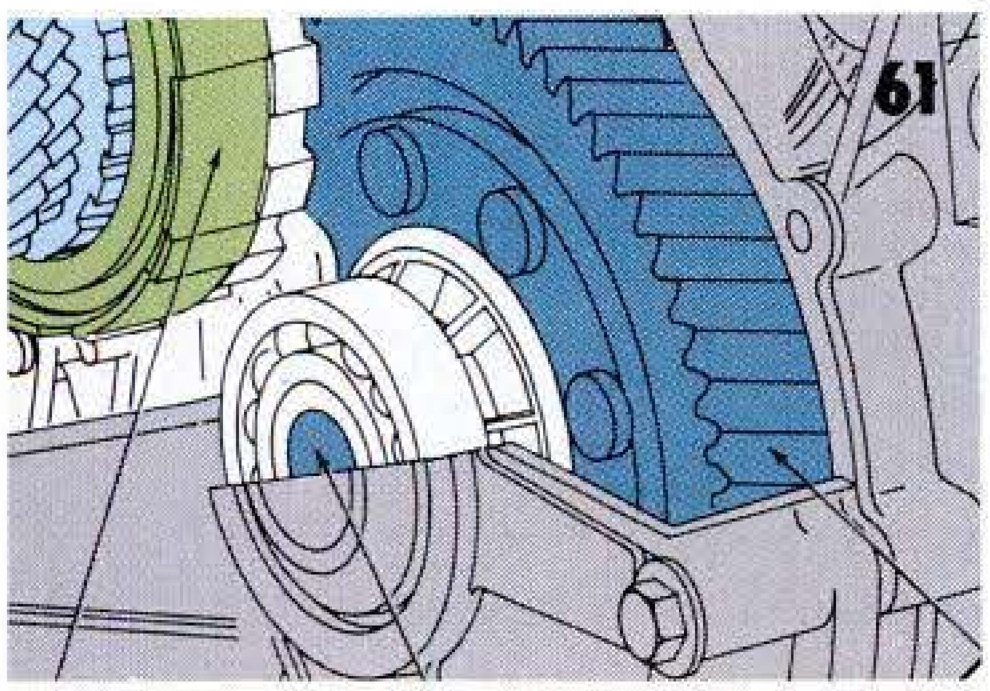
Popular Science

AUGUST 1990
Founded in 1872/Vol. 237, No. 2

COVER STORY

Sun racers

In a race fueled exclusively by the sun, 32 college teams will head north from Florida to Michigan in their home-built, featherweight, ultra-sleek cars, competing for top honors in the 11-day Sunrayce USA. The top three finishers will gain passage to the World Solar Challenge to be held in Australia in November.

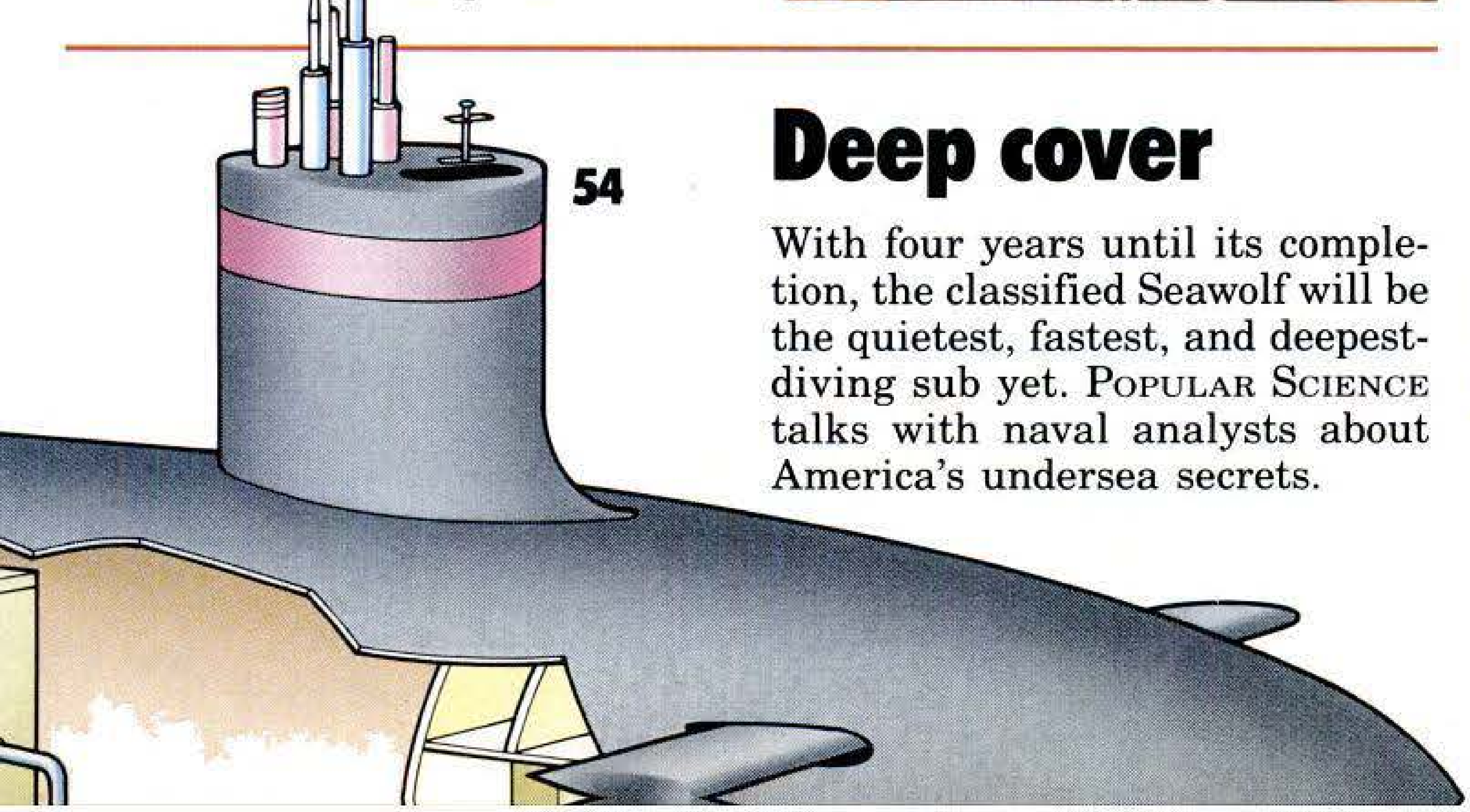


Inside Saturn

General Motors takes on new strategies in its attempt to produce a low-cost quality compact car. The once-top-secret Saturn may surprise its Japanese competition.

Pocket phones

New wireless phone systems—personal communication networks—will use spread-spectrum technology to solve many problems associated with portable and cellular phones.



Deep cover

With four years until its completion, the classified Seawolf will be the quietest, fastest, and deepest-diving sub yet. Popular Science talks with naval analysts about America's undersea secrets.

WHAT'S NEW DIGEST 14–24

SCIENCE AND TECHNOLOGY

Landslide for safer nuclear 6
What's new 14
Science newsfront 26
Deep cover 54
Satellite catapult 70

COMPUTERS AND ELECTRONICS

What's new electronics 16
What's new photography 17
Electronics newsfront 30
Stereo for two.......................... 58
Computers without keys......... 66
Personal pocket phones 74

CARS AND DRIVING

What's new automotive........... 18
Automotive newsfront............. 36
Sun racers 49
Inside Saturn............................ 61
Car test:
  the wedge vs. the box 76
Material wealth 82
"Say, Smokey—"....................... 90

HOME PRODUCTS AND TECHNOLOGY

What's new tools 19
What's new outdoor tools 22
What's new home..................... 24
Home newsfront 42
Clean-air paints 85

ADDITIONAL FEATURES

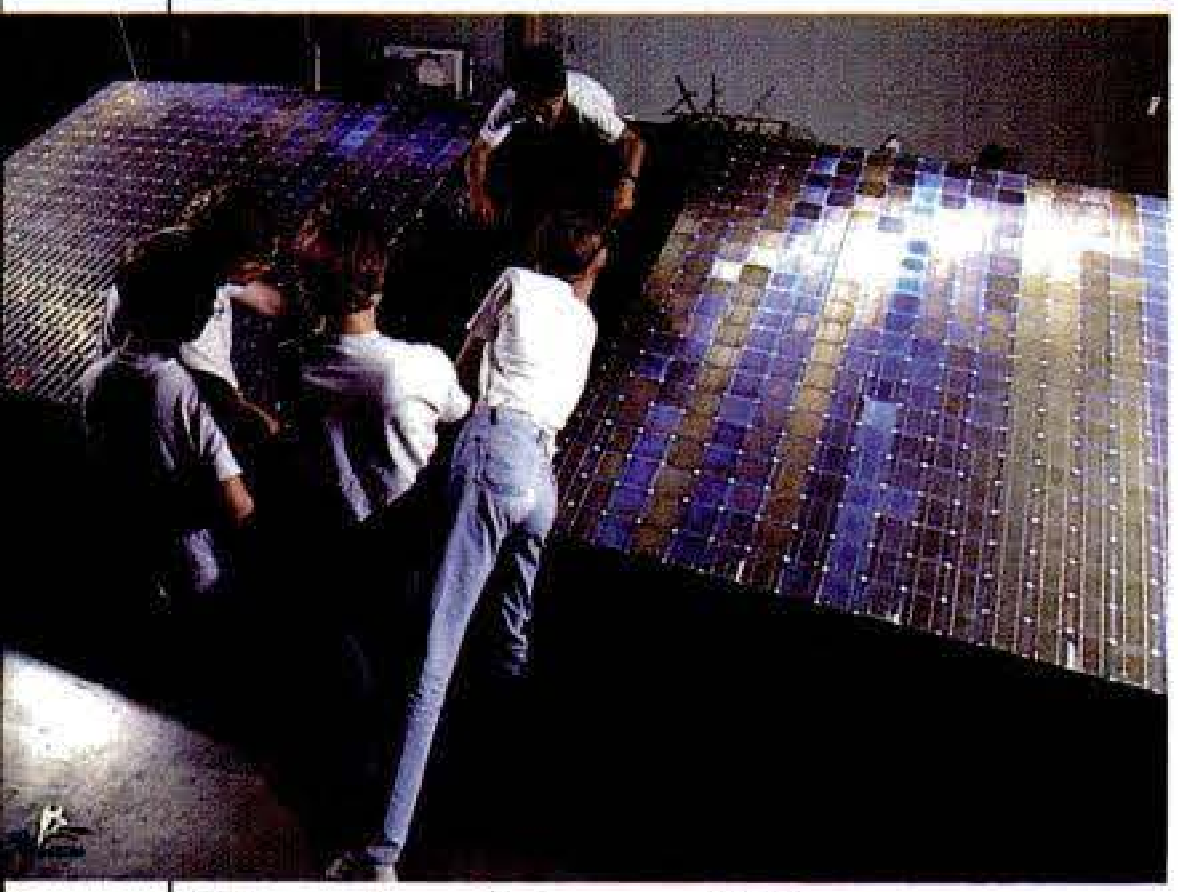
What's news 4
Readers talk back..................... 8
Product information............... 101
Looking back 102

COVER PHOTO
BY PHIL SCHOFIELD

What's News

If you're interested in some eye-filling high-tech adventure this summer, let me suggest a sojourn on the two-lane blacktops between Epcot Center in Orlando, Fla., and the General Motors Technical Center in Warren, Mich., during the daylight hours of July 9th through the 19th. There you'll likely encounter the strange vehicle depicted on this month's cover—or any number of 31 others equally startling. Be forewarned: You have strayed into the midst of Sunrayce USA, a 1,600-plus-mile competition of solar-powered vehicles.

Typical of these sun racers, Associate Editor Brian Nadel reports, is one car that "looks like a cross between an armadillo and a pup tent on wheels." Strange styling, in this case, to serve an almost impossible engineering feat. "Think of it as driving a car at fifty miles per hour on the power of a hair dryer," says one participant.



The solar-car team of Western Washington University.

No one is suggesting that a practical road-worthy sun-powered vehicle is in the offing. But as a research-and-development exercise, it has enormous potential for engineering and design spinoffs. The collegiate designers of the Sunrayce vehicles are pushing the envelope on aerodynamics, solar-cell generating efficiencies, weight-saving composite-material usage, and other principles and components that will eventually make a difference in vehicles ranging from aircraft to cars.

At Popular Science, we think the innovation underpinnings of the Sunrayce to be so potentially important, we have joined with the Department of Energy, one of the race sponsors, to award the Popular Science Engineering Excellence Award to the vehicle that demonstrates the best overall design. A $2,000 scholarship will be awarded to the winning school. Highlights of the Sunrayce and the engineering award winner will be covered in a follow-up report in our October issue.

Speaking of follow-ups, on page 6 you'll find the results and analysis of our poll on next generation nuclear reactors. Our telephone poll brought forth more than 5,000 respondents (including a controversial get-out-the-electronic-vote effort on the part of one major nuclear-generator designer), and more letters than we've received on a single story in recent memory. Our letters editor, Mariette DiChristina, was struck by the depth of opinion as well as the volume of mail. "It was emotionally and intellectually driven," she explains. "Many letters went on for pages—and, interestingly, environmentalists came in both pro and against nuclear power." I think you'll find our poll analysis and the mail sampling as interesting and provocative as the article itself.

As we get closer to the traditional fall automotive introduction season, it seems fitting that we offer you a wealth of automotive-technology news in this issue. In "Material Wealth," Senior Editor Dan McCosh gives his driving impressions and a technical tour of Honda's new NSX sports car, which boasts the most extensive use of aluminum construction in a production car in recent times. "A breakthrough has been achieved," McCosh notes, "that is likely to influence family cars of the future."

General Motors' family car of the future is the Saturn. McCosh and Senior Editor Norman S. Mayersohn wheedled their way into a closely chaperoned—one might say, tightly guarded—tour of Saturn's built-from-the-ground-up state-of-the-art production plant, just before it was put off-limits to outsiders. What they saw was a radical new way to build a car that is now in early production and will be in dealer showrooms this fall.

Editor-in-Chief

Popular Science

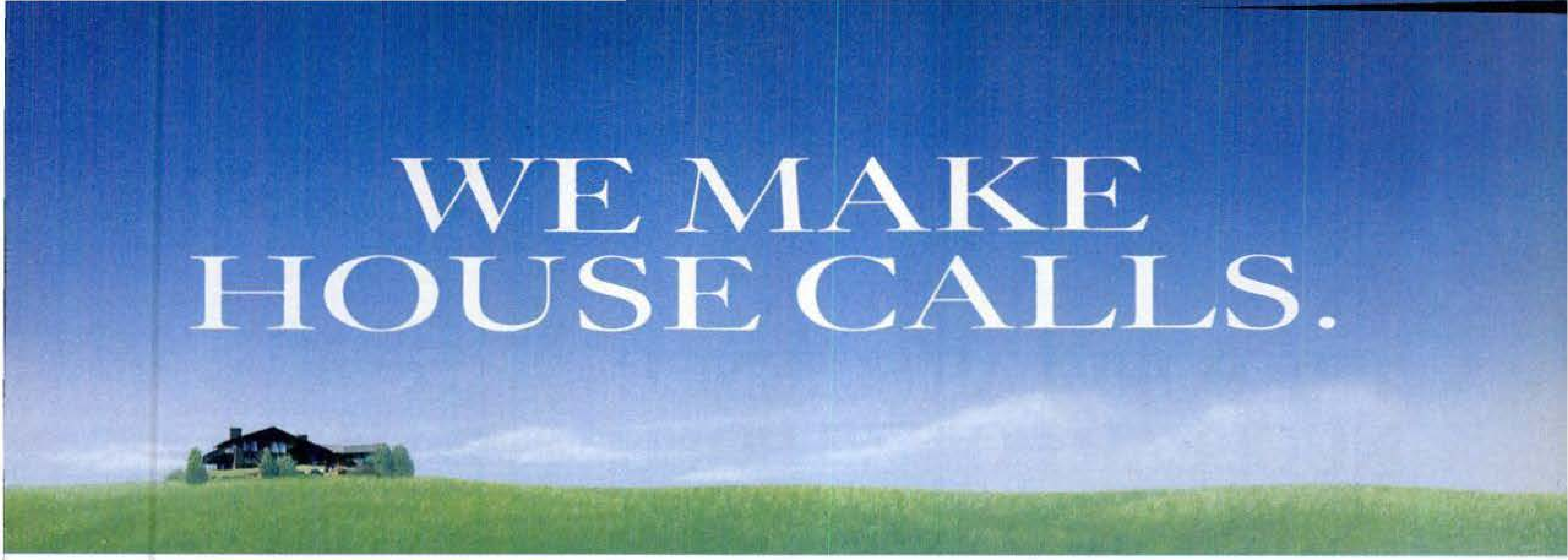
Editor-in-Chief Fred Abatemarco

Editor Herbert Shuldiner
Executive Editor Richard L. Stepler
Art Director W. David Houser
Science & Technology Editor Arthur Fisher
Copy Chief Sherrill Clarke
Senior Editors
Timothy O. Bakke, John Free,
V. Elaine Gilmore, William J. Hawkins,
Norman S. Mayersohn, Dan McCosh
Associate Editors
Stuart F. Brown, Mariette DiChristina,
Brian Nadel, Dawn Stover
Copy Editors Stefanie Benado,
Nancy Negovetich
Assistant Editor Judith Anne Yeaple
Staff Photographer John B. Carnett
Art Editors Richard J. Meyer
W. Thomas White
Art Associate Hugo Salhuana
Picture Editor Cynthia van Roden
Deputy Picture Editor Caren Friedman
Automotive Norman S. Mayersohn
Brian Nadel *Associate*
Dan McCosh *Detroit*
Don Sherman *Special Projects and Testing*
Electronics William J. Hawkins
Home Improvement Timothy O. Bakke
Housing Technology V. Elaine Gilmore
Lawn & Garden Timothy O. Bakke
Photography Arthur Fisher
Recreation Stuart F. Brown
Tools V. Elaine Gilmore
European Correspondent David Scott
West Coast Correspondent J.T. Johnson
Editorial Assistant Marcelle M. Soviero
Editorial Business Manager
Roberta S. Lee

CONSULTING EDITORS
R. J. De Cristoforo *Shop Techniques*
Robert Gannon *Science*
A. J. Hand *Tools*
Ben Kocivar *Aviation*
E. F. Lindsley *Outdoor Power Equipment*
Phil McCafferty *Home & Shop*
Stephen Mercaldo *Auto Maintenance*
Everett H. Ortner *Photography*
Evan Powell *Appliances, Home Equipment*
Smokey Yunick *Auto Mechanics*

POPULAR SCIENCE **BUSINESS AND EXECUTIVE OFFICES:** 2 Park Ave., New York NY 10016. **EDITORIAL OFFICES:** Address contributions to Popular Science, Editorial Dept., 2 Park Ave., New York NY 10016. We are not responsible for loss of unsolicited queries, manuscripts, photographs, transparencies, or other materials. They will not be returned unless accompanied by return postage. Microfilm editions are available from Xerox University Microfilms Serial Bid Coordinator, 300 N. Zeeb Rd., Ann Arbor MI 48106. **SUBSCRIPTION INQUIRIES:** Send new or renewal subscriptions or change of address (send both new and old addresses) to Popular Science, Box 54965, Boulder CO 80322-4965. Allow six to eight weeks for change of address. If you have a subscription problem, please write to the above address or call (800) 289-9399. Subscriptions: U.S. and its possessions, 1 year $13.94; 2 years $24.97; 3 years $34.97. For Canada, add $5 per year. For Foreign, add $8 per year. Subscriptions processed electronically. **POSTMASTER:** Send change of address notices to Popular Science, Box 54965, Boulder CO 80322-4965. Popular Science entered as second-class postage paid at New York NY and additional mailing offices. Also entered as second-class matter at the P.O. Dept., Canada. Popular Science (ISSN 0161-7370) is published monthly by Times Mirror Magazines, Inc., 2 Park Ave., New York NY 10016. Printed in the U.S.A.

Copyright © 1990 by Times Mirror Magazines, Inc. All rights reserved. Contents may not be reprinted or otherwise reproduced without written permission. Popular Science® Mechanics and Handicraft®



Introducing our Nationwide In-Home Service program – where there's no such thing as a Reliance water heater *too* remote for us to service.

It figures. With 8,000 trained professionals coast to coast plus a 7-day toll-free number, we're ready to help you no matter where you happen to live – on natural gas lines or in propane country.

How can we offer such a service? Simple. Reliance gas water heaters, including our top of the line Sta-Kleen models, are so reliable, we don't expect you'll be calling all that often. But if you do, rest assured. We'll either solve your problem over the phone or come to your house within 24 hours. Maximum.

For more information on the Reliance In-Home Service program and Sta-Kleen self-cleaning gas water heaters, call 1-800-365-4054.

RELIANCE®
WATER HEATER COMPANY
Ashland City, Tennessee

© 1990 American Gas Association

Choose one of our gas water heaters and reduce your operating costs. Gas heats water for 1/2 the cost of electricity.

GAS. AMERICA'S BEST ENEI

This One
FBTC-NPN-D1BT

Copyrighted material

THE POPULAR SCIENCE NUCLEAR POWER POLL

LANDSLIDE FOR SAFER NUCLEAR

By a stunning majority, voters in the POPULAR SCIENCE poll [Cast Your Vote On Next Generation Nuclear Power, April '90] favor building a new generation of nuclear power plants. Responding to our detailed report on nuclear plant designs and concepts claimed to be safer than existing nuclear generating stations, voters from 38 states took part in the poll and more than 5,600 persons cast electronically recorded ballots on the main issue: Should the United States build more fossil-fuel power plants or the new so-called safe nuclear generators to meet the energy crisis of the '90s? The pro-nuke voters prevailed by a margin of more than six to one.

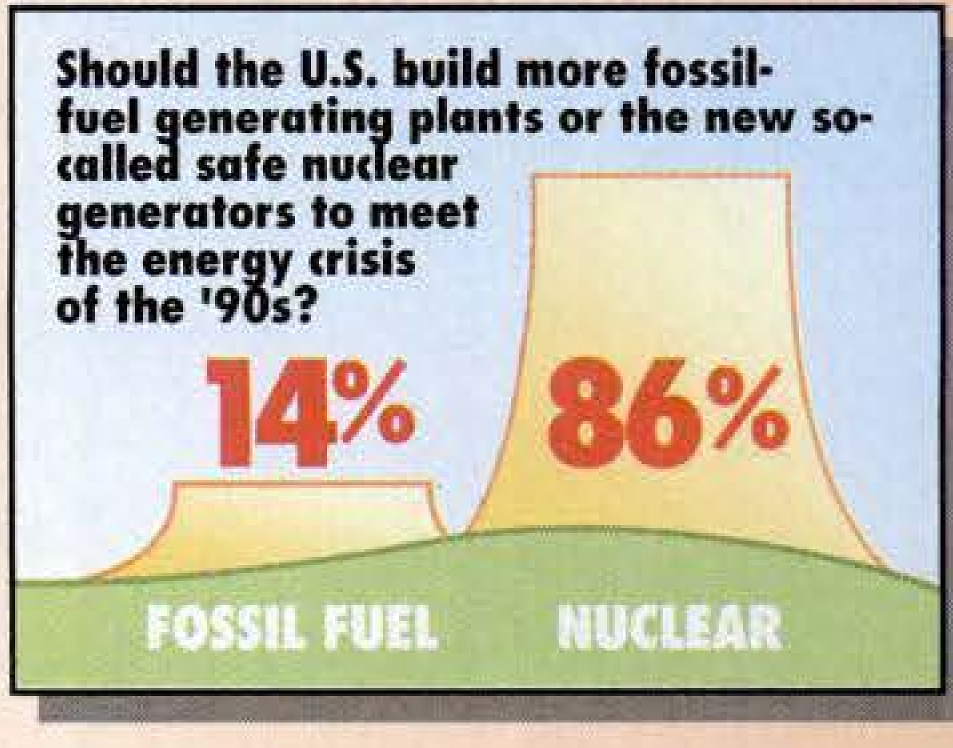
Why did the vote turn out in this fashion? In follow-up interviews, voters said that nuclear power in a new package could meet energy needs in a safe, environmentally friendly way. Said one voter in Oklahoma City: "It's also better than acid rain." The Oklahoma reader also said he was in favor of building "little ones rather than mega ones." A New Jersey minister told us that "more people have gotten sick from Jane Fonda movies than from nuclear power."

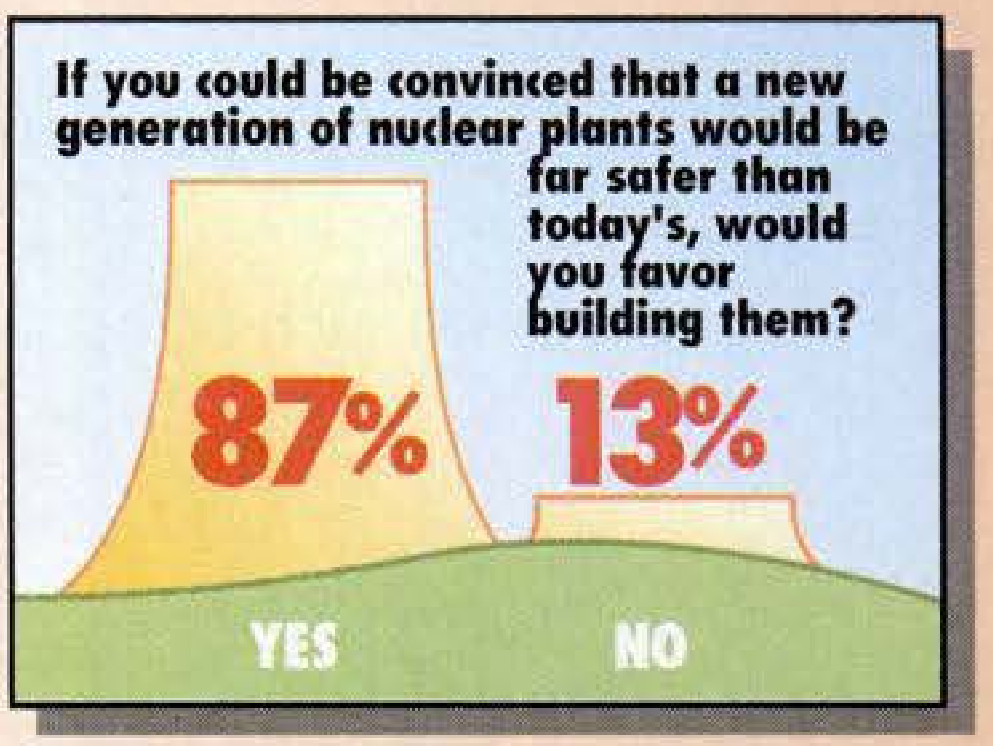
A huge majority of voters also indicated a preference for nuclear power research over alternate energy. In addition, the tally showed disapproval of the government's energy policies.

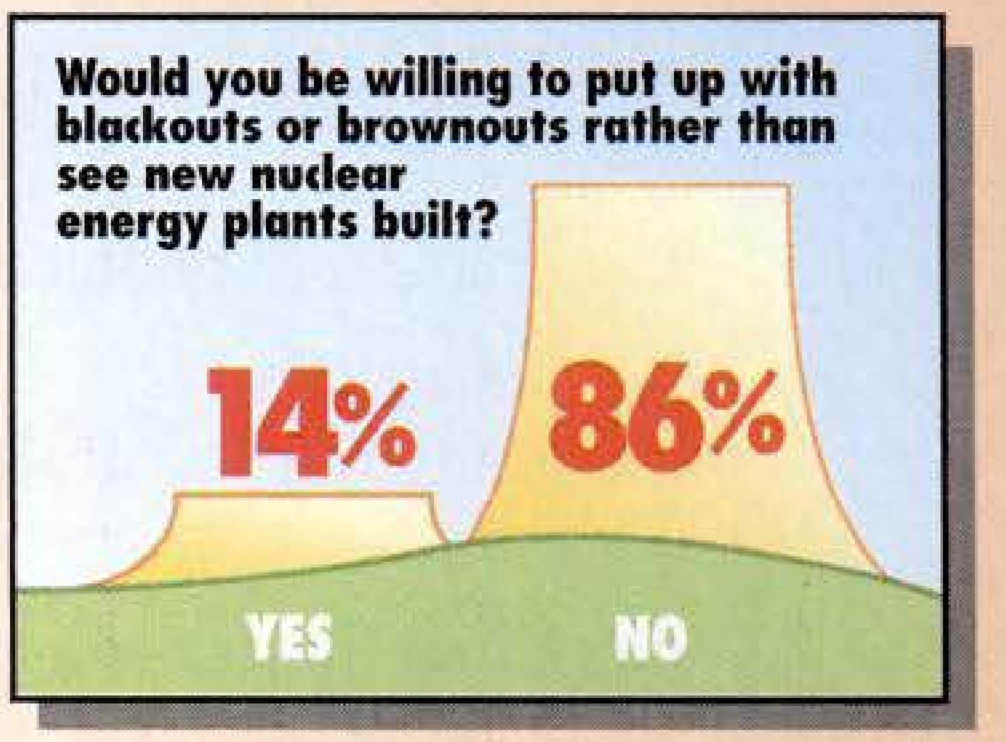
The vote was clear-cut despite an attempt on the part of Westinghouse, one of the world's major nuclear power plant designers, to stuff the electronic ballot box. Westinghouse set up a special speed dialing number, enabling its Pittsburgh headquarters employees to call our 900 poll number (which cost voters 75 cents a minute) for free, and then publicized the article and poll in an internal newsletter. Westinghouse employees responded with a total of 20 percent of the total votes cast in our poll, according to our research.

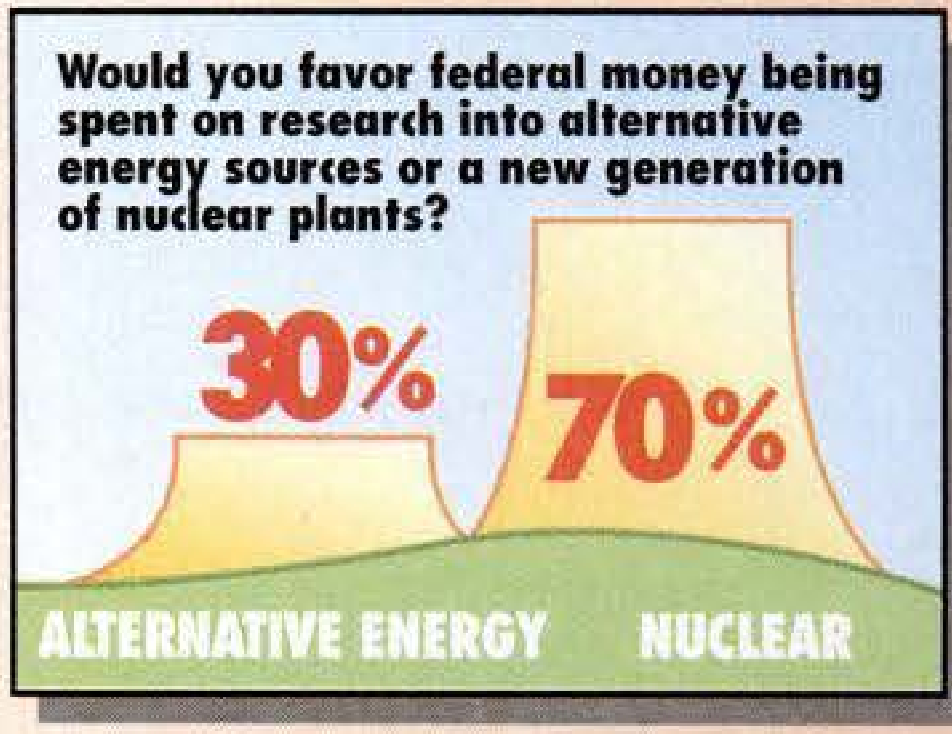
(POPULAR SCIENCE protested the actions of Westinghouse, criticizing the nuke manufacturer for a sinister and cynical disregard for an open and honest forum of free ideas. Richard Slember, vice president of Westinghouse's energy systems, replied: "We in no way tried to influence any votes, but we did want our employees to know about the poll and to

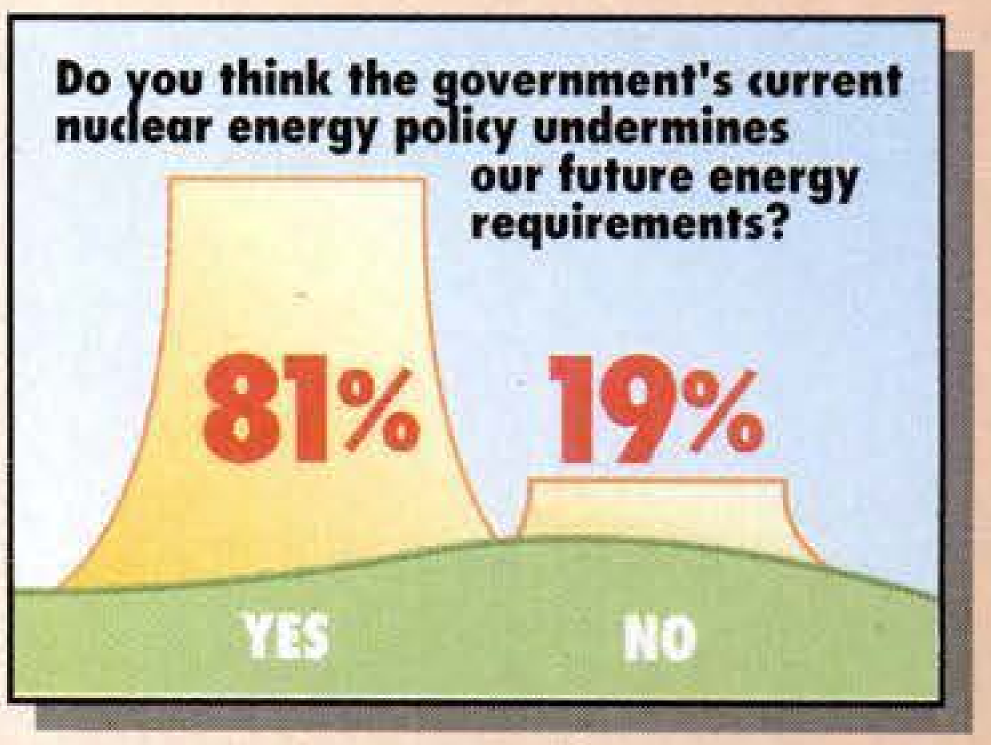
A GRAPHIC LOOK AT THE PHONE POLL











have the opportunity to participate.")

Even when these votes are discarded, the result is a landslide favoring the building of a new generation of safer nuclear plants. If we assume that all the votes originating from Westinghouse were pro nukes and disqualify them, the margin is still about five to one in favor of the new nuclear plants.

Voting on the second question, which posed the issue of safety, and on the question that asked if respondents would rather put up with blackouts than see new nukes built, revealed that there is less concern about safety than might be supposed. And there's definitely no strong sentiment for cutting back on energy consumption.

A California student explained his pro vote this way: "You're more likely to be struck by lightning twice than hurt by nuclear power." And a Coloradan simply explained his pro vote with: "It's a necessary evil, we have to have it."

Our April cover article also provoked the greatest volume of letters we've received for one story in recent memory. In these, there was a distinct trend *against* the proposed new generation of nuclear power plants, although the ratio was less pronounced: 60 percent to 40 percent (a sampling appears in the box at right).

Voters who opposed the new nukes also had strong feelings on the subject. One negative vote was cast by a Reno, Nev., cook who declared, "Scientists are destroying our society. I've lost all confidence in these people."

Some voters simply told us that there are no easy solutions to the energy problem—that fossil and nuclear fuels both posed threats to mankind. But virtually all of these comments came from people who voted in favor of the new nukes.

The voting also revealed a preference for spending more money on nuclear-energy research rather than on alternate-energy research. However, in our exit poll calls, there were a number of respondents who indicated that alternate energy is a viable alternative to nuclear and fossil fuels. And, by a margin of four to one, the voters also expressed a deep distrust of the government's energy policies. The vote indicates that there is a strong feeling that the government's energy policy undermines future needs.

Copies of the April article, the results of our poll, and the letters will be forwarded to leading policy makers, including President Bush.

OUR READERS COMMENT

To provide a comprehensive national plan for the Department of Energy's nuclear-reactor program, I introduced legislation, along with Chairman Marilyn Lloyd of the House Science, Space, and Technology Subcommittee on Energy, Research, and Development and others. This strategy will ensure that advanced-reactor technology activities are conducted in a cost-effective and coordinated manner. I believe nuclear-generated electricity can meet our future energy needs safely, reliably, and efficiently. As we take steps to clean up our air, nuclear energy must be a part of the national debate.

Rep. Richard H. Stallings
Congress of the United States, House of Representatives, Washington, D.C.

Nuclear-generated electricity is currently our most viable source of energy going, and it is the cleanest and most readily available alternative to conventional power plants. I think nuclear power will eventually be replaced by power from wind, geothermal, and solar—once they become economic and practical. In addition, regarding the safety record of nuclear reactors: With proper care and monitoring, accidents are preventable. No industry is without its down side (e.g., the oil industry and its spills), and there are no gains without such risks.

Robert Mander, Kanata, Ontario, Canada

I agree that a standardized design would solve many of the problems associated with operating and licensing nuclear reactors. But at the same time, I'm worried that we have scant experience in decommissioning large reactors. And these new advanced designs do little, if anything, to take this into consideration. Compounding this is the industry's inability to handle the problems of radioactivity. Until these issues can be fully addressed, I think the construction of second generation nuclear reactors should be put on hold.

Kurtis Kurzmann, San Antonio, Texas

You state in your article that the challenge against storing nuclear waste at Yucca Mountain was because of concerns about rain leaching the radioactivity; this isn't the whole story. Not only do we Nevadans not want to be a dump for the entire nation, but we are also concerned because Yucca is part of the Nevada Test Site, where underground nuclear bombs are routinely detonated and is a geologically unstable area. People seem to think that burying the waste here will keep it out of their backyards, but stop to think: The waste must be shipped across the country to get here—with many opportunities for accidents along the way.

J. Sloane, Las Vegas, Nev.

I work in the nuclear industry and would not continue to do so if it really meant leaving my son a "world pockmarked by nuclear-waste and meltdown sites," as one reader suggested ["Readers Talk Back," June]. The reason I specialized in environmental radiological sciences was because I am interested in protecting the environment. Regarding radioactive-waste disposal, even in the worst case the legacy of nuclear power would be insignificant radiation doses, mere fractions of natural background radiation. And once disposed of, radioactive isotopes decay to non-radioactive elements; the same is not true of many other hazardous wastes, which do not decay at all. I am disappointed that POPULAR SCIENCE didn't present more factual information on currently available disposal technology and actual health risks resulting from nuclear-waste disposal. Who knows? People might find out that the nuclear-waste problem isn't technical at all, but political.

Vincent A. King, Wichita, Kan.

Fission-type nuclear reactors should be outlawed before they contaminate our underground water supply and the air we breathe.

Matthew C. Jay, San Diego, Calif.

Your article glossed over important nontechnical issues that are the real stumbling blocks to the future of nuclear energy in the United States: politics and fear. Some people will selectively fear and oppose nuclear-generated energy no matter what facts are presented to them. Arguing over the technical merits of one reactor type versus another won't change their minds. Ironically, some of these same people have absolutely no fear of lying out in the sun, while in reality they are absorbing radiation from that big fusion reactor in the sky.

Joseph F. Lesyna, P.E., San Jose, Calif.

Flying is statistically one of the safest ways to travel. Yet people are killed every year in air crashes. Thousands are killed in automobile accidents. But no one would take seriously a headline like, "Compact Sedans—Dare We Build Them?" While these deaths are actual, deaths attributed to commercial nuclear power-plant accidents are hypothetical. (Chernobyl is not comparable because it uses a vastly different technology.) If you assess risk within its defined context, you'll find that the current generation of commercial nuclear technology provides the safest way to generate electric power when compared with fossil, hydro, or solar.

Chris O'Hara, Fairfield, Conn.

Today's nuclear reactors are already far safer than any other form of energy generator. And it is sheer hypocrisy to find deaths from cars and smoking acceptable (product ads your magazine carries) while questioning the safety of nuclear power plants, which have killed no one.

Gary Seinen, Port Alberni, British Columbia, Canada

Readers Talk Back

Horsing around with hp?

Assuming 100 percent conversion to mechanical energy, there are 746 watts in one horsepower. The air compressors in "Plug-in-Anywhere Air Power" [May] are limited to 15 amperes at 115 volts—or 1,725 watts. So even if these motors were 100 percent efficient—an impossibility—they only would produce 2.3 hp. Where does that leave the three-hp compressors? Well, I figure about half of their rating is for compressing air, and the rest is hot air from the advertising departments.

Richard J. Byrd, Annandale, Va.

Using accepted definitions of output motor horsepower, we find the "three-hp" compressors probably don't produce a full two hp on a continuous-duty basis. We will give $1,000 to the first person who shows us a true continuous-duty three-hp electric-motor-driven air compressor that runs on a single-phase 115-volt 60-cycle current without drawing more than 15 amperes.

Gilbert D. Williamson, president
Champion Pneumatic Machinery Co.
Princeton, Ill.

While it is more useful to compare the cubic feet of air per minute that compressors can deliver, they are sold based on rated horsepower. Rated horsepower is not the same as standard electrical horsepower. Part of the evaluation hinges on "breakdown" torque—the point where torque drops rapidly under load. To be rated at three hp by the National Electrical Manufacturers Association, a 115-volt compressor with a single-phase induction motor must exert at least six pound-feet of torque at breakdown—a specification met or exceeded by all of the compressor motors in my story. Because of questions on relative power, however, the Home Air Compressor Association (composed of the four manufacturers in the article) is preparing new industry guidelines. —Phil McCafferty

Can't recycle? Compost it!

It may be difficult to recycle Popular Science's glossy clay-coated paper ["RTB," Feb., May], but it's not hard to compost it. We have mixed ground-up magazine paper and sewage sludge to make Type 1 compost, a grade judged by New York state's Department of Environmental Conservation as suitable for use on all vegetation but food crops.

Lewis M. Naylor, senior vice president
International Process Systems
Ithaca, N.Y.

PS at $27.88 a year?

Regarding the question of finding recycled paper that would be affordable for Popular Science ["RTB," May], this reader would gladly pay double the subscription price so he could feel comfortable about the usage of the paper and our Earth.

G. Harman, Cucamonga, Calif.

Tree topics

In "Reinventing Wood" [May], you referred to *Pinus radiata* as "a fast-growing Australian pine." I thought it was a North American native.

John Humbert, Volcano, Calif.

Monterey pine, as the species is commonly called, is native to Southern California, says Dr. Norman S. Richards, a professor at the State University of New York College of Environmental Science and Forestry in Syracuse. However, it is a commercial timber in Australia because it grows better there than it does in this country.

The Melaleuca tree was planted as a solution to the bareness of the Florida Everglades, and now it is considered a pest by some environmental groups. Can Parallam use it in reconstituted wood?

Haik Donikian, Miami, Fla.

Melaleuca hasn't yet been tested to make Parallam beams, but our experience with other varieties of hardwood and softwood suggests the process would work well with almost any species. Our Athens, Ga., manufacturing plant makes strong beams from small and sometimes poorly formed tree trunks of Loblolly and Shortleaf pine, for example. We plan to study other species, such as Sweet gum and Melaleuca, in the coming years.—M. T. Churchland, manager, technology, MacMillan Bloedel Ltd., Annacis Island, British Columbia, Canada

Statistical inaccuracy

I disagree that lightning kills more people than other natural hazards ["Predicting Deadly Lightning," May]. Actually, in an average year, floods kill 60 percent more people than lightning. Over a 20-year period, flooding has caused an average of 163 deaths annually; tornadoes, 98; lightning, 97; and hurricanes, 33. I originated these statistics as head of the National Weather Service's Natural Hazard Preparedness and Awareness Program, and continue to compile data as a meteorological consultant.

Richard A. Wood
Tucson, Ariz.

Chip slip

The synthetic speech output from the Geostar receiver is not a voice chip, as you said in "Hello Satellite, Get Me Central" [April]. Our proprietary text-to-speech conversion technology is hardware-independent software, and can be implemented on a variety of hardware platforms for different products. For Geostar, we developed a plug-in unit that attaches to the company's message receiver. The unit incorporates standard chips: an 8088 microprocessor, a TMS320-10 digital signal processing chip, and some memory chips.

Elisabeth W. Peters
General Manager
Berkeley Speech Technologies
Berkeley, Calif.

Let's not meet by accident

While the modular composite-fiber chassis in "Plastic-Chassis Taurus" [May] offers lighter weight and cheaper manufacturing costs, you missed one important aspect: How difficult is it—and how much would it cost—to repair the car after an accident?

William Huber, Mobile, Ala.

Repairability is only one of many considerations Ford engineers are studying now that the plastic Taurus exists. My guess is that crash-damaged areas would be sawed out of the car body and new sections bonded in place. After extensive damage, however, the car would be a total loss, as is the case with today's steel bodies. —Don Sherman

Still-safer takeoffs

The cockpit simulator is a good idea ["Safer Takeoffs for Airliners," April]. But when faced with aborting a flight, pilots should also be able to employ a drag chute, like those used to slow military planes and drag racers. A retrofitted airliner might get its tail jerked off in an aborted flight, but that beats what happened to the USAir plane, which went into the drink at New York City's La Guardia Airport last year.

Roland Gautsche, San Diego, Calif.

New life for an old idea

The tree-canopy raft used to study tropical insects hit a nostalgic chord ["What's New," April]. As a machine gunner in Vietnam, I tried a version of this theory 25 years ago. Instead of conducting lengthy searches for landing zones, a huge nylon net was dropped on the treetops and fastened to them; we were to rappel from the choppers onto the net, then hook onto its weblike ropes and rappel the remaining distance down to the jungle floor. It was a fiasco! The instability of the bamboo trees, combined with the weight of our backpacks, weapons, and ammunition, rendered the plan unsafe to say the least. But I am glad scientists have made this old idea work—for research, not war.

James F. Breen, Newtown, Pa.

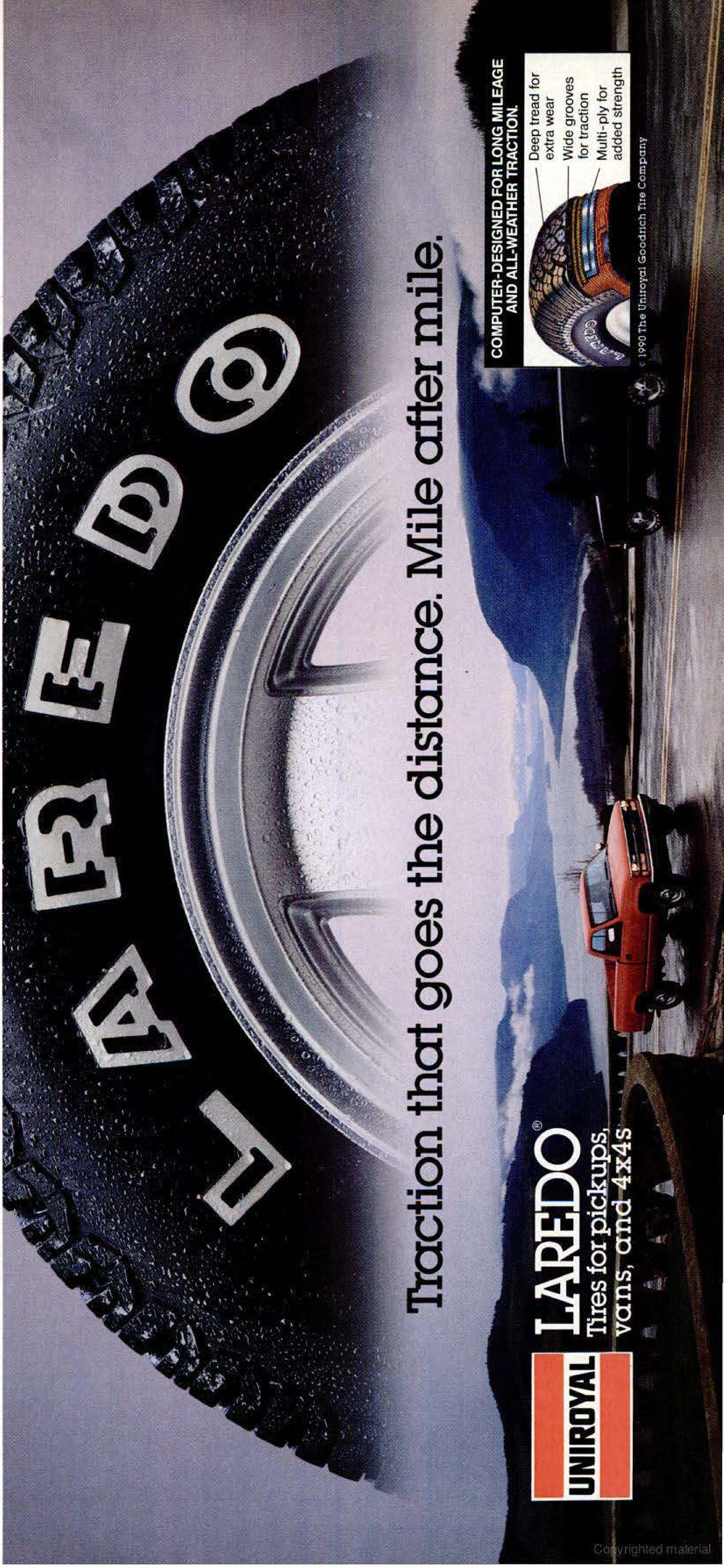
Road barrier: bonus or bane?

After reading about the International Barrier Corp.'s new highway barriers ["Automotive Newsfront," April], I became interested enough to contact IBC engineers for more information. Please continue publishing such articles: As a traffic-safety officer, I know that engineering and education are two major ingredients to making both roads and vehicles safer for all of us.

Patrolman Michael D. McCrae
Township of Manchester Police Dept.
Lakehurst, N.J.

As a Florida commuter, I have seen the IBC MK-5 and MK-7 highway barriers. Whenever I pass a place where a traffic mishap has occurred, I notice the torn and twisted sheet metal that used to cover the top of the IBC barrier. Because the edges of this metal can be sharp and these sheets are about throat high, they seem capable of inflicting serious cuts. I think more research and development is in order.

Fred W. Cunningham
Wilton Manors, Fla.


LAREDO
Traction that goes the distance. Mile after mile.
COMPUTER-DESIGNED FOR LONG MILEAGE AND ALL-WEATHER TRACTION.
Deep tread for extra wear
Wide grooves for traction
Multi-ply for added strength
UNIROYAL
LAREDO®
Tires for pickups, vans, and 4x4s
© 1990 The Uniroyal Goodrich Tire Company

Readers Talk Back

Significant damage—whether a ruined lid on an IBC barrier or a chunk knocked out of a concrete barrier—is best repaired promptly by the local highway authority. Nonetheless, because both barriers are wider at lower points than at their peaks, it is unlikely that any part of a car would contact existing damage at the top of either system. In addition, the IBC barrier's deformed steel reflects a beneficial design characteristic. Unlike rigid concrete, the barrier sacrifices itself to save the lives of those who strike it by keeping the vehicle essentially level and cushioning the impact.—Lincoln C. Cobb, head of design, International Barrier Corp., Claysburg, Pa.

For the record

While it's true that my son, Mark, has been credited with designing the Mazda Miata, he did not create the yellow roadster named the Micro, in which we are displaying the General Motors two-stroke engine ["Automotive Newsfront," April]. The Micro was developed in 1985 at GM Design by Elia Russinoff. Let's give Mazda engineers credit—they got the car on the road and we didn't.

C. M. Jordan, vice president
General Motors Design
Warren, Mich.

The nose knows

As an Alaska resident who has just had his favorite mosquito repellent recalled because massive doses of one ingredient cause health problems—and who now sits at his word processor with over 200 of the critters in view on his window screen—I am happy to note the relationship between two recent articles. In "The Man Who Upset the Apple Cart" [Feb.], Bruce Ames eats an orange and notes that the main ingredient in citrus oil is D-Limonene, a carcinogen. Ames says, "People don't want to come to grips with a world that is full of carcinogens. I'm going to rub their noses in it." I am glad POPULAR SCIENCE took a step to help Ames rub people's noses in it. In "Home Newsfront" [June] the writer uses a cleanser containing D-Limonene on her hands—a good idea, but the wrong part of her anatomy!

Al Cook, Central, Alaska

All evidence supports the Food and Drug Administration position that D-Limonene, both in foods and in products applied topically, poses no health hazard to the consumer. The FDA has not found any cause for removing D-Limonene from its Generally Regarded as Safe (GRAS) list of chemicals. There is no movement within the FDA or pressure by any agency or group to challenge the GRAS status of D-Limonene. In addition, the Safe Drinking Water and Toxic Enforcement Act of California (known as California Proposition 65) does not list D-Limonene as a carcinogen or a reproductive toxicant.—John Lamade, product manager, Loctite Corp., Cleveland, Ohio.

Warped view of high speed?

"Traveling at Warp Speed" [May] shows that as you approach light speed, a distortion like a fisheye lens occurs. Have you forgotten the Doppler effect? As you approach light speed, there would be an increase in the frequency of the electromagnetic radiation viewed in the direction of travel. In other words, you wouldn't see light as you do now. The visible spectrum of light would shift into the X-ray region and beyond, depending on speed. To the rear, light frequencies would shift into infrared, then to radio signals as you increase speed.

Eddie Washburn, Bostic, N.C.

The article included only images of the spacial (geometric) distortion of relativistic imaging. The effect of the relativistic Doppler color shift, however, is indeed supported by our simulation software.—Ping-Kang Hsiung, Carnegie Mellon University, Electrical and Computer Engineering, Pittsburgh, Pa.

Editor's notes: The credit for the photo of the Blackbird SR-71 in July's "Science Newsfront" was omitted. The photo was taken by Bernie Boston of the *Los Angeles Times*.

The schematic of the house wiring, shown on the screen of a Tandy computer in "Integrated, Automated, Educated House" [June], is generated by software from US West in Phoenix.

Address letters to Readers Talk Back, POPULAR SCIENCE, 2 Park Ave., New York, N.Y. 10016. Or fax your letter to us at (212) 779-5468. We reserve the right to edit for space and clarity and cannot answer unpublished letters.

PHOTOCOPY PERMISSION: Permission is granted by *Popular Science*® for libraries and others registered with the Copyright Clearance Center (CCC) to photocopy articles in this issue for the flat fee of $1 per copy of each article or any part of an article. Send correspondence and payment to CCC (21 Congress St., Salem, Mass. 01970); specify CCC code 0161-7370/85/$1.00—0.00. Copying done for other than personal or reference use without the written permission of *Popular Science*® is prohibited. Address requests for permission on bulk orders to Chief Editorial Asst., Popular Science, 2 Park Ave., New York NY 10016. *Popular Science*® is a registered trademark of Times Mirror Magazines, Inc.

Popular Science

Publisher John B. Crawley

Advertising Director Ron Bernstein

ADVERTISING OFFICES

NEW YORK
2 Park Ave., New York NY 10016
(212) 779-5000
Manager Michele Folman
Ed Baker, Noël Lucky,
Claudia Ryan, Avery Stirratt
Promotion Manager Harry Fleischman
Production Director Gerald Palacios
Production Manager Carol Gilbert Jones
Makeup Manager Yvonne King
Makeup Assistant Oris D'Amil
Director, Classified Operations Richard Goldberg
Assistant to the Publisher Jeanette Conner
Advertising Coordinator Deborah Price
Brenda Charles, Lizzette Millan

MIDWEST
625 N. Michigan Ave., Chicago IL 60611
(312) 337-7717
Manager William Plane
Susan Lulich, John Zeman

WEST COAST
3550 Wilshire Blvd., Los Angeles CA 90010
(213) 380-1936
Manager James P. Docherty

SOUTHEAST
1 Concourse Pkwy., Suite 740, Atlanta, GA 30328
Manager Gregg R. Hano
(404) 804-5998

DETROIT
755 W. Big Beaver Rd., Suite 420, Troy MI 48084
(313) 362-9005
Manager Robert Reynolds
Direct Response Manager Diane Pahl
Nancy Ludeman

Times Mirror Magazines

Published monthly by
TIMES MIRROR MAGAZINES, INC.
2 Park Ave., New York NY 10016
ISSN 0161-7370

Chairman of the Board EDWARD E. JOHNSON
President and Chief Executive Officer
FRANCIS P. PANDOLFI
Executive Vice President/Editorial Director
EZRA BOWEN
Executive Vice President/Group Publisher
JAMES L. KOPPER
Executive Vice President, Operations
PATRICIA G. CAMPBELL
Senior Vice President, Finance MICHAEL J. HAUGH
Deputy Editorial Director C. P. GILMORE
Group Publisher JOHN B. CRAWLEY
Vice President, Circulation DIANE G. POTTER
Vice President, Business Development
GERTRUD BORCHARDT
Vice President, Controller JOHN D. MARTIN
Vice President, Manufacturing KIT TAYLOR
Vice President, Planning SCOTT KABAK
Group Marketing Director PAUL ZUCKERMAN
Research Director STEVEN R. GREENBERGER
Promotion Director JAMES M. GIRALDEZ
Marketing Director DEB LEES
Circulation Director MICHELE JEHLE
Corporate Sales Development Manager
MICHAEL EDISON
Conservation Council Executive Director
DAVID B. ROCKLAND

ONE STEP AHEAD

The Best Radar Detector Ever Made Is Now Even Better. What Does That Mean to You? PLENTY.

How Can The Best Get Better?

The answer to that question is simple: The new ESCORT picks up radar signals from farther away than ever was possible before...in its new, smaller, streamlined case.

Advanced Computer Technology: What's New Under the Handsome Case

The all-new ESCORT literally uses space-age technology—Digital Signal Processing (DSP), the same advanced system NASA uses to "sharpen" radar images.

If you like technical talk, here's what DSP does: It samples incoming radar signals 50,000 times a second. Information is digitized and analyzed by a signal-recognition computer.

The heart of ESCORT's DSP circuitry is a custom version of the Motorola DSP 56000. This 20 MHz 24 bit parallel HCMOS processor is capable of 10.25 million instructions per second, and is also used in Steve Jobs' new $10,000 NeXT computer.

Result? Greater distance than any detector ever had before. Greater separation of garbage-signals. Incredibly fast reaction to instant-on traps. Better protection than any driver could have had before.

And oh, yes: The case itself is aluminum, finished in non-glare black...not cheap plastic.

A New High Level of Safety and Protection

The new ESCORT brings you up to a level of protection no radar detector could provide before. You no longer will wander into a sudden "beep-explosion," too late to slow down. Even distant "instant-on" radar doesn't faze this mighty detector.

Early warning is well beyond the capability of early detectors without ESCORT's power and sensitivity. You know the value of radar warning. You should know, too—Only one detector is most powerful: ESCORT.

Here's What the Experts Say

"If you are a fan of the old Escort, you are really going to love the new Escort...The unit is the first to utilize Digital Signal Processing (DSP) to sniff out weak radar signals."

—*Sport Truck*

"A new automobile radar detector picks up weaker signals than was previously possible, thanks to Digital Signal Processing (DSP)."

—*Machine Design*

"The new Escort uses Digital Signal Processing, something not used before in other than military applications."

—*Stock Car Racing*

"The new Escort packs ultimate sensitivity into a small package. Nothing else even comes close, and no wonder...No analog device can hope to match this performance."

—*BMW Roundel*

- Just ⅞" high, 3¼" wide
- Visor clip and adjustable windshield mount
- Alert lamp glows on radar contact
- Variable-pulse warning
- Hewlett-Packard LED bar graph shows radar proximity
- Photocell adjusts display to car's light level (dark mode for discreet operation)
- Adjustable volume and mute switch (including "automute" to turn down volume after first alert)

Thieves Know: They Can't Use a Stolen ESCORT!

ESCORT has a tiny "Digital Key." Use it to unlock your ESCORT when you first get it, then every couple of months. Without the key, ESCORT won't work.

Thieves know this. When they spot an ESCORT, smart crooks move on to the next car.

It Costs No More to Have The Best

ESCORT costs $295. That's actually less than some radar detectors with a fraction of ESCORT's ability. We've built more than two million PASSPORT and ESCORT radar detectors, and we stand behind every one of them.

But—

You don't risk one cent to find out for yourself just how much protection ESCORT gives you. Use it for one full month. If for any reason you think you can get along without it, send it back and we'll send you a complete refund, even including your return shipping costs. What could be fairer than that?

Use ESCORT for One Month at Our Risk

Order by Toll-Free Phone 24 Hours a Day, Seven Days a Week.

Call toll-free 1-800-543-1608

ESCORT®
RADAR WARNING RECEIVER

$295 Ohio residents add $16.23 tax. Higher in Canada.

A product of Cincinnati Microwave, maker of PASSPORT and ESCORT.

Cincinnati Microwave
▶ Department 501680
One Microwave Plaza
Cincinnati, Ohio 45249

© 1990 CMI

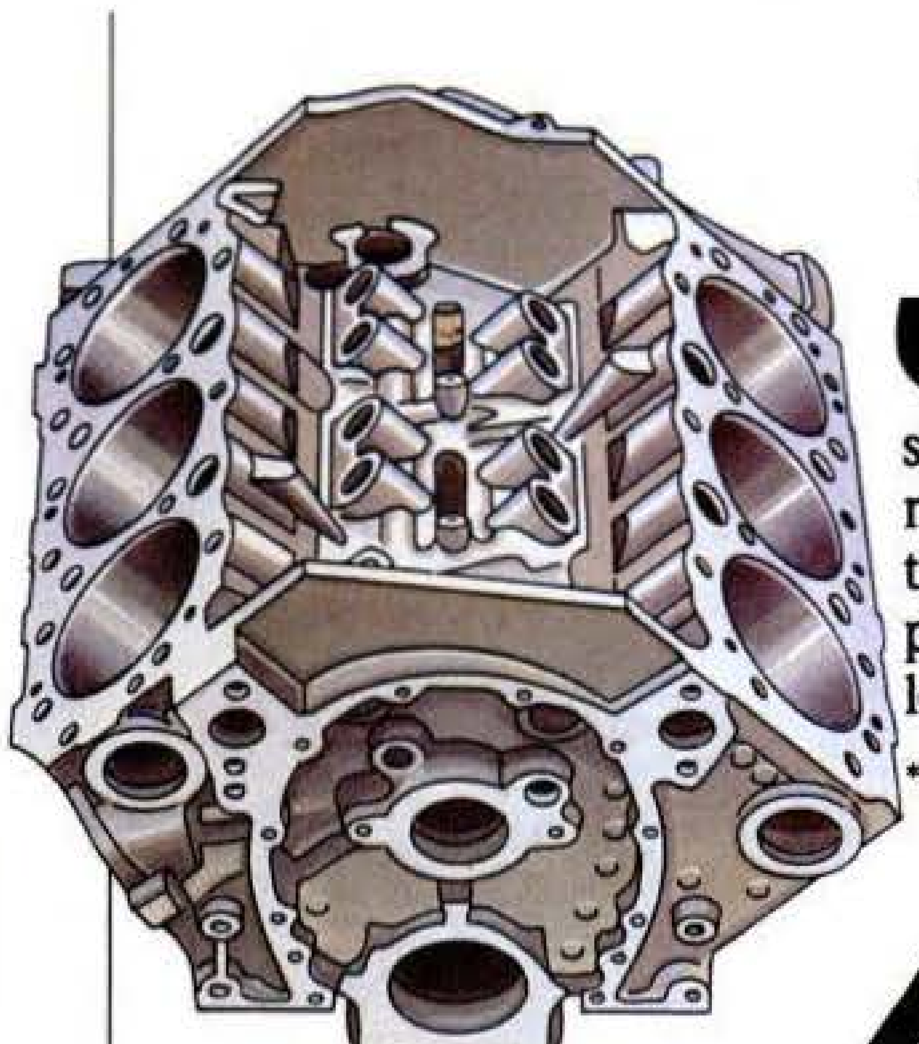
Yesterday's work truck isn't good enough anymore.

TODAY'S NEW CHEVY WORK TRUCK

1 New Duragrille.

Chevy Work Truck's new grille is built strong to help resist stone damage. Because our new Work Truck has to do more than look pretty. It's built to work.

Yesterday's truck is history. Today's Chevy Work Truck is ready to go to work for you. Today.



3 More standard 1/2-ton power than Ford.

Chevy Work Truck's standard 4.3L Vortec V6 puts 10% more horsepower to work for you than Ford's standard Six. And it's priced hundreds less than the lowest-priced Ford.*

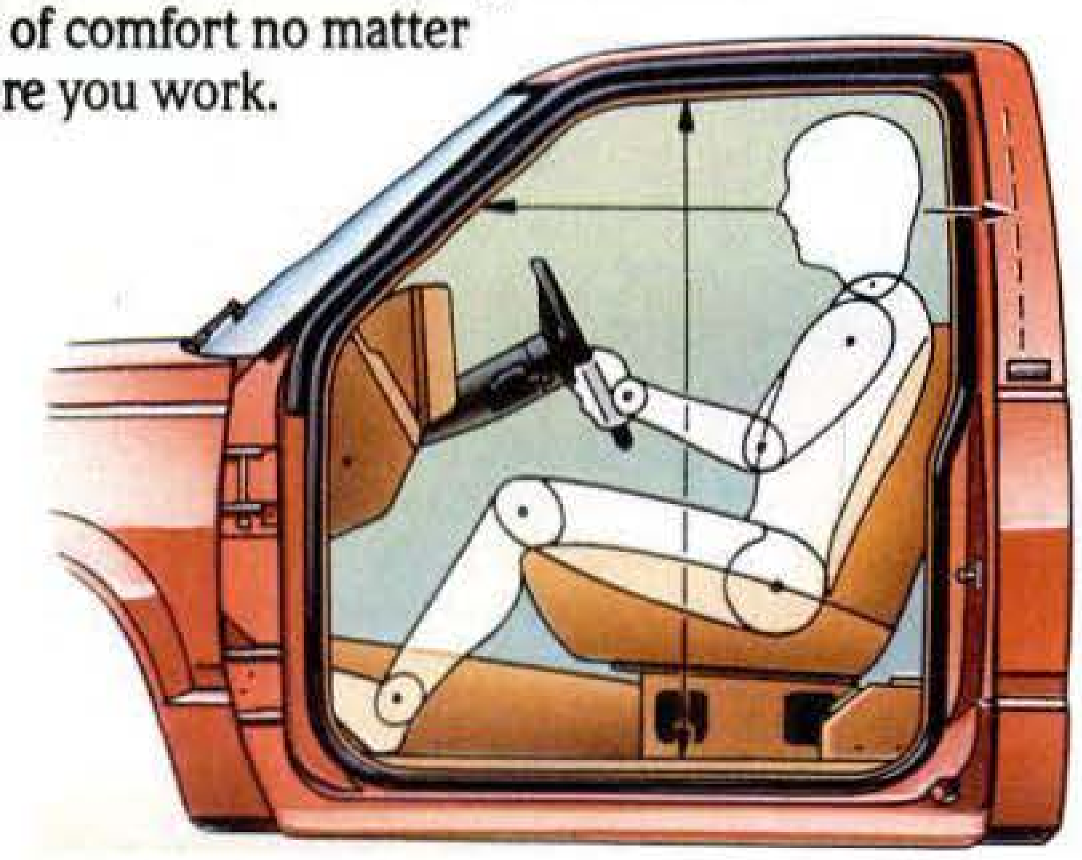
*Based on Manufacturer's Suggested Retail Price.

4 Heavier Gross Vehicle Weight Rating than Ford.

The 2-wheel-drive Chevy Work Truck's 5600-lb. GVWR, including passengers, cargo and equipment, beats Ford in working ability day in, day out.

2 More total cab room than Ford.

Chevy gives you more leg room. More shoulder room. More total cab room than yesterday's pickup from Ford. And when you add Chevy's excellent ride and visibility, that means a lot of comfort no matter where you work.



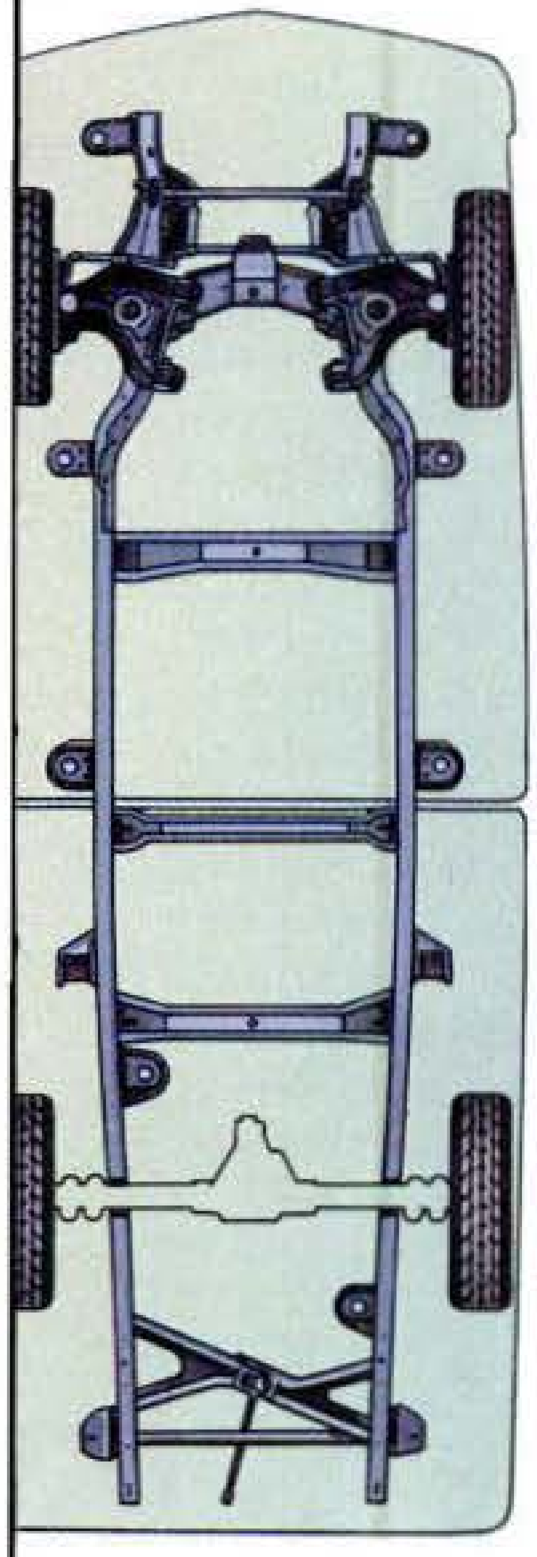
5 More two-sided galvanized steel than Ford.

More of Chevy's body panels are made of two-sided galvanized steel, front, sides and rear. Including the cargo bed. So your Chevy will fight corrosion for years. Plus a hot-wax chassis treatment to help seal the frame from road salt and chemicals. You can't get that on a Ford.

Chevrolet and the Chevrolet emblem are registered trademarks and Chevy is a trademark of the GM Corp. ©1990 GM Corp. All Rights Reserved.

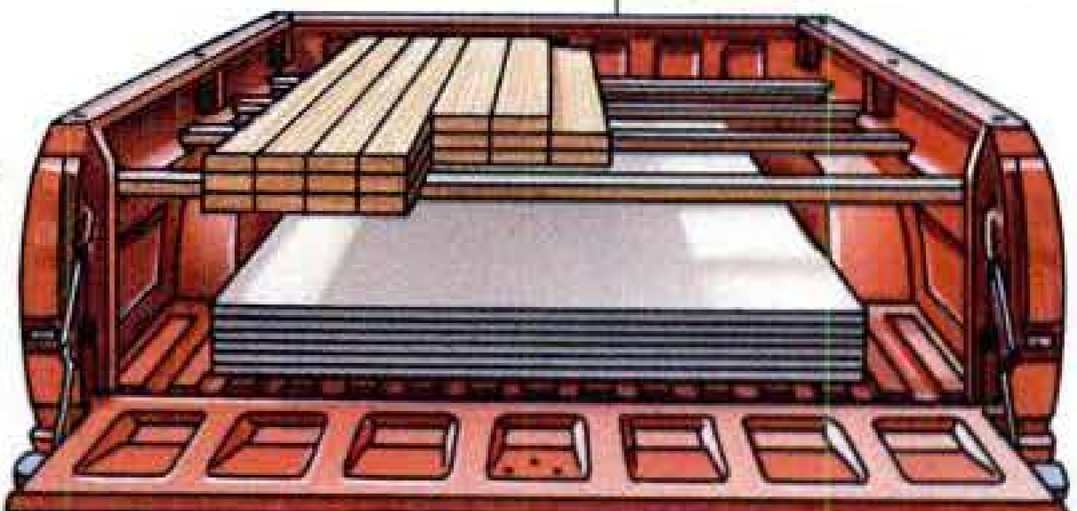
Let's get it together...buckle up.

OUTWORKS FORD 10 WAYS.



6 Bigger, heavier 4x4 frame than Ford.

Chevy's full box-section "Strongbox" frame construction up front is stronger than Ford's "C"-section. And Chevy's frame is bigger and heavier overall, too.



7 Two-tier loading Ford doesn't have.

Put 2x6 planks in the pickup wall grooves, and you've got a platform to carry just about anything. While your tools and other materials stay conveniently stowed underneath.

8 More ground clearance than Ford.

On site or off road, you need a pickup that won't leave you high-centered. And Chevy Work Truck's high-stance construction can take you over obstacles Ford's ½-ton pickup can't clear.

9 3-year/50,000-mile Bumper to Bumper Plus Warranty.†

It covers hundreds of nonpowertrain parts 2 years longer than Ford's. Electrical parts. Chassis parts. In fact, everything but the tires, which have their own warranty.

GM
BUMPER TO BUMPER PLUS
3 YEAR/50,000 MILE WARRANTY

†See your Chevrolet dealer for terms of this limited warranty. A deductible applies after 12 months or 12,000 miles.

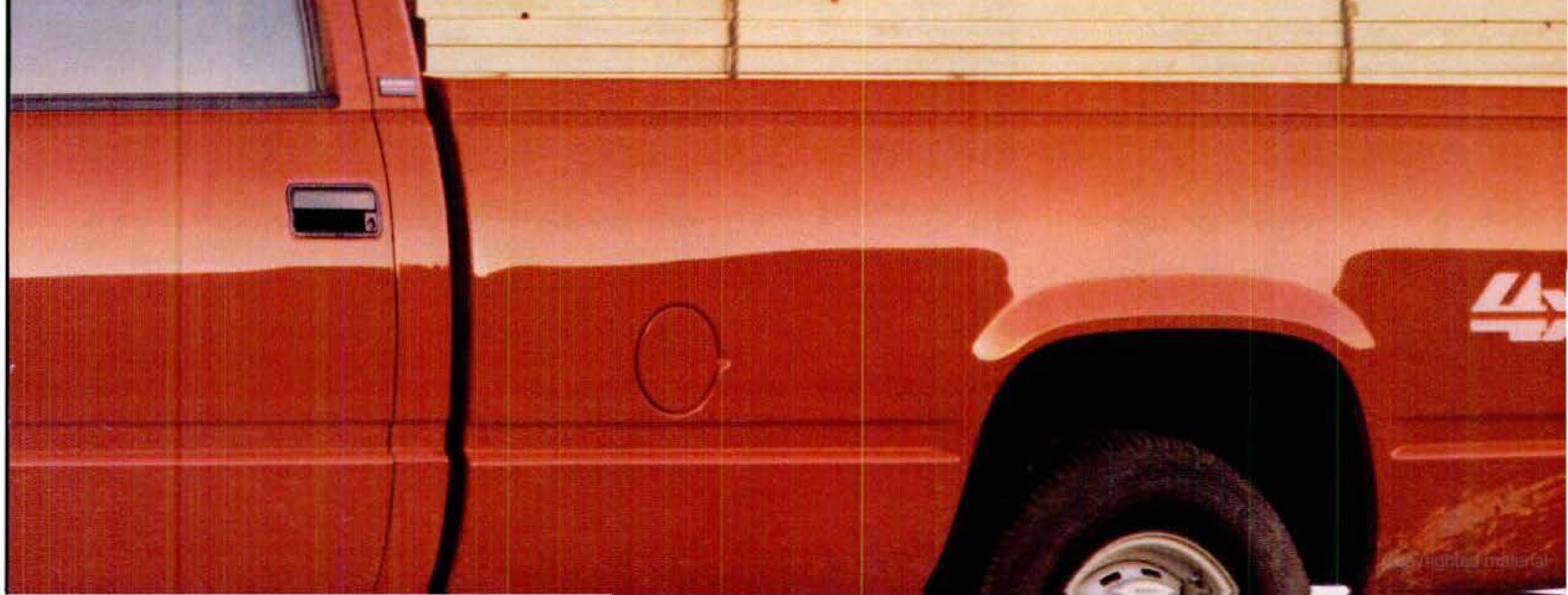
4x4 INSTA TRAC™

10 Standard shift-on-the-fly Insta-Trac™ 4WD.

Chevy revolutionized 4-wheel drive years ago with Insta-Trac, the first system that lets you shift in and out of 4-wheel drive without stopping or backing up. The new Chevy Work Truck continues that tradition — when the conditions demand, you just shift and keep right on going.

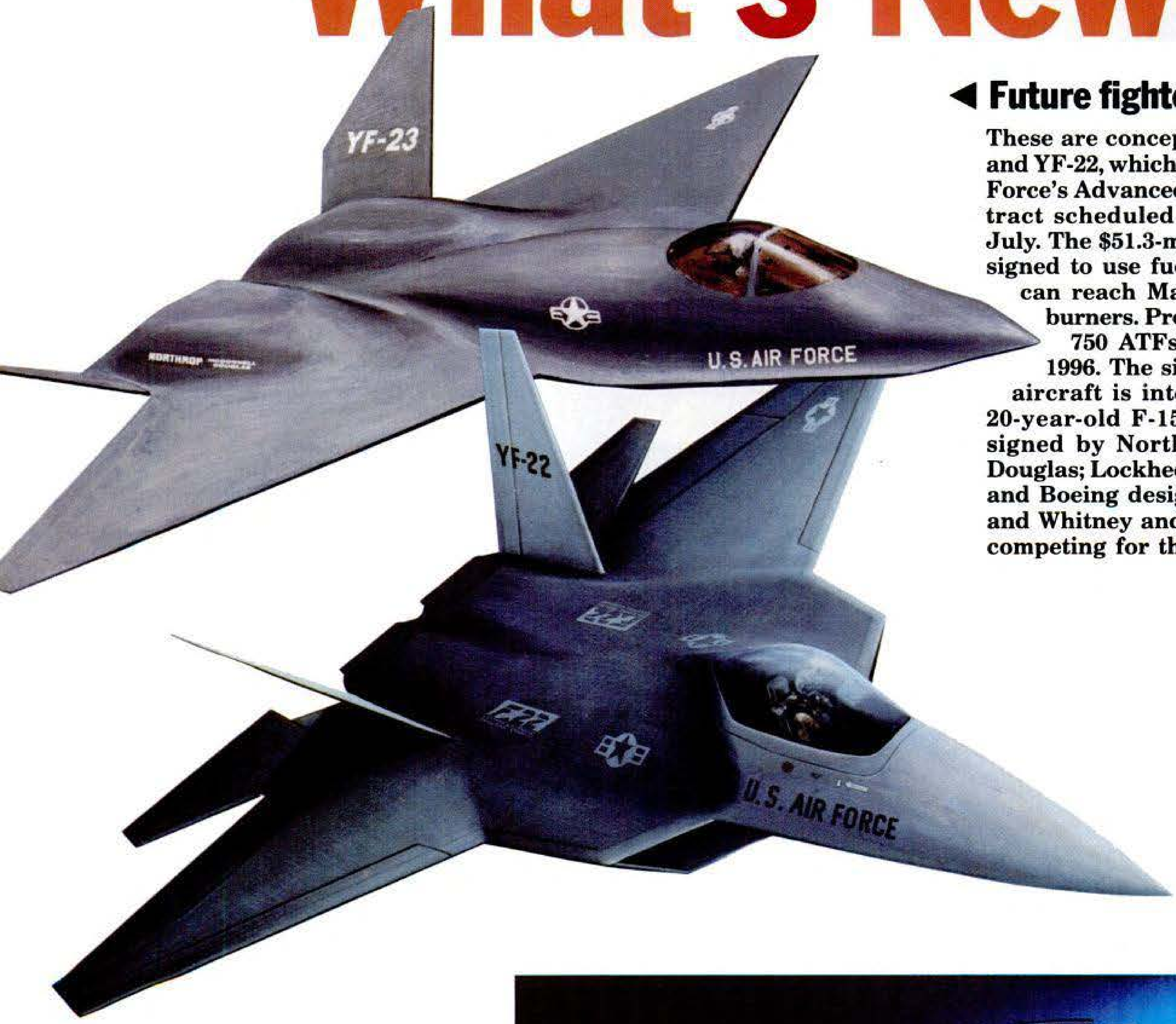
And that's 10 solid reasons why nobody's winning like The Heartbeat of America.

THE Heartbeat OF AMERICA IS WINNING TODAY'S TRUCK IS CHEVROLET™



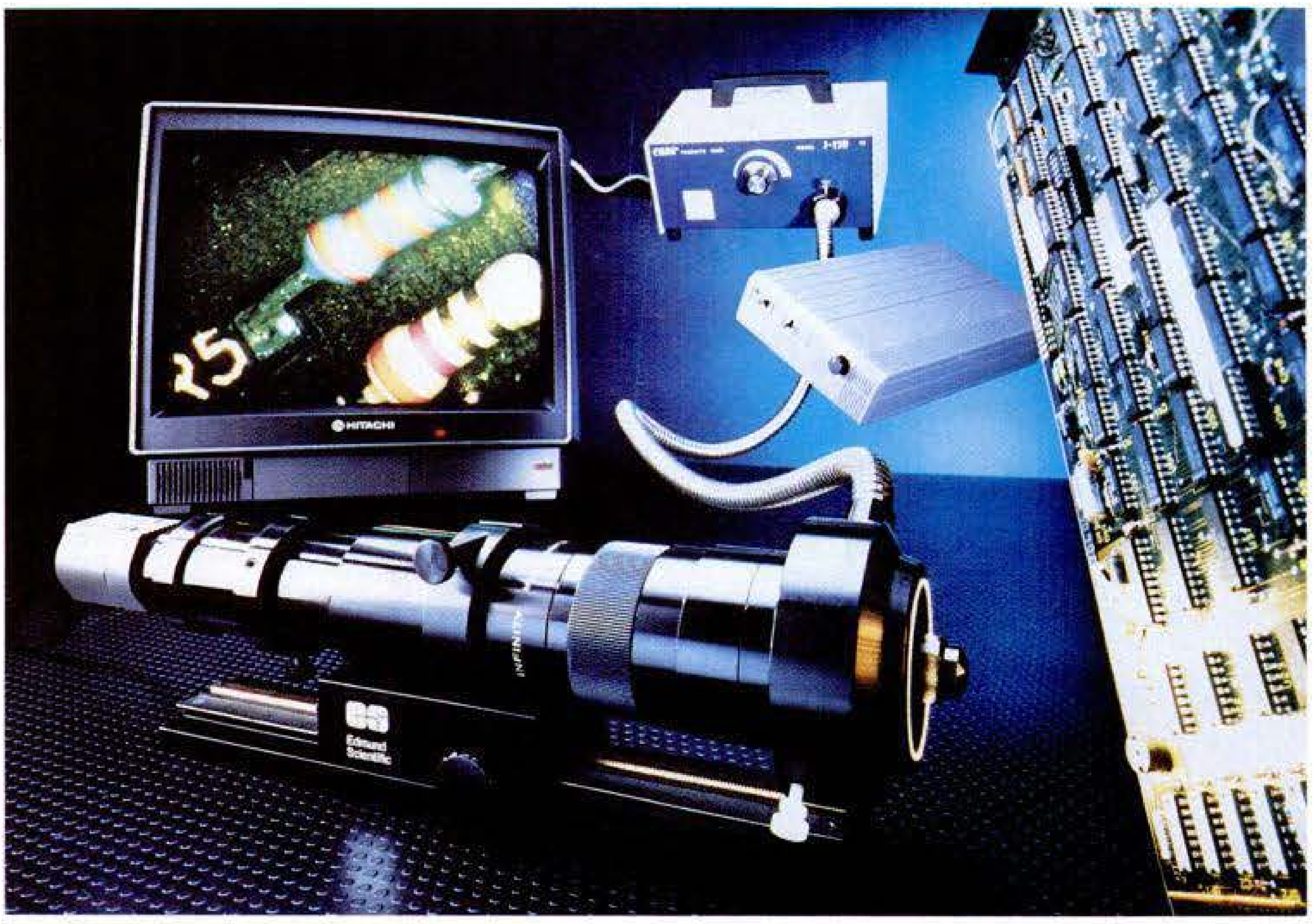
BY JUDITH ANNE YEAPLE

What's New



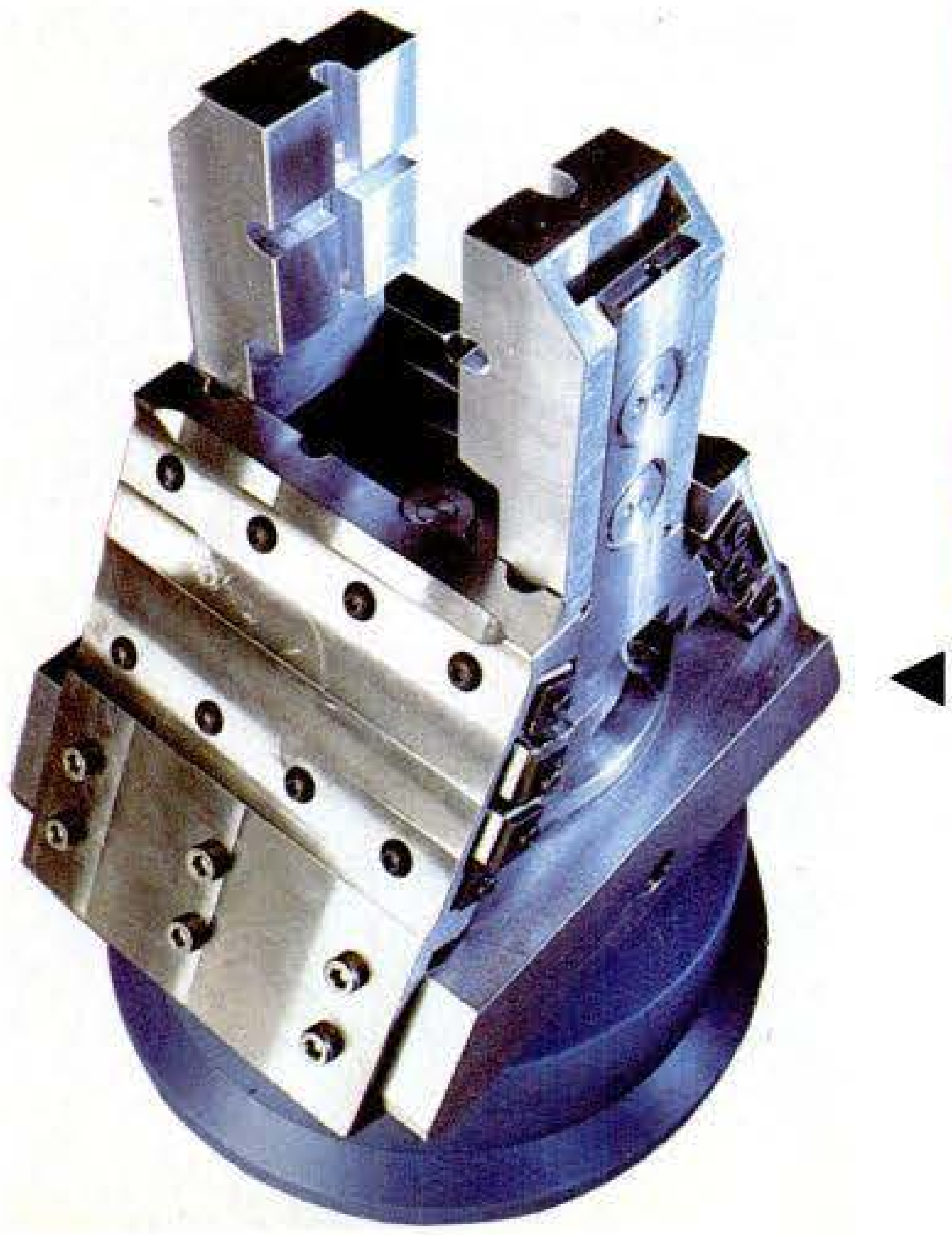
◀ Future fighter

These are concepts for the YF-23 (top) and YF-22, which are dueling for the Air Force's Advanced Tactical Fighter contract scheduled to be awarded next July. The $51.3-million ATF will be designed to use fuel-stingy engines that can reach Mach 1.5 without afterburners. Production of as many as 750 ATFs is slated to begin in 1996. The single-seat twin-engine aircraft is intended to replace the 20-year-old F-15. The YF-23 was designed by Northrop and McDonnell Douglas; Lockheed, General Dynamics, and Boeing designed the YF-22. Pratt and Whitney and General Electric are competing for the engine contract.



Flexibly focusing microscope ▶

The Continuously Focusable Microscope lets you refocus while moving to as close as 6mm or as far as 150mm. Magnification is 90 times with a 10× eyepiece. The $3,075 device can be teamed with a video camera and screen. Edmund Scientific Co., N999 Edscorp Building, Barrington, N.J. 07094.

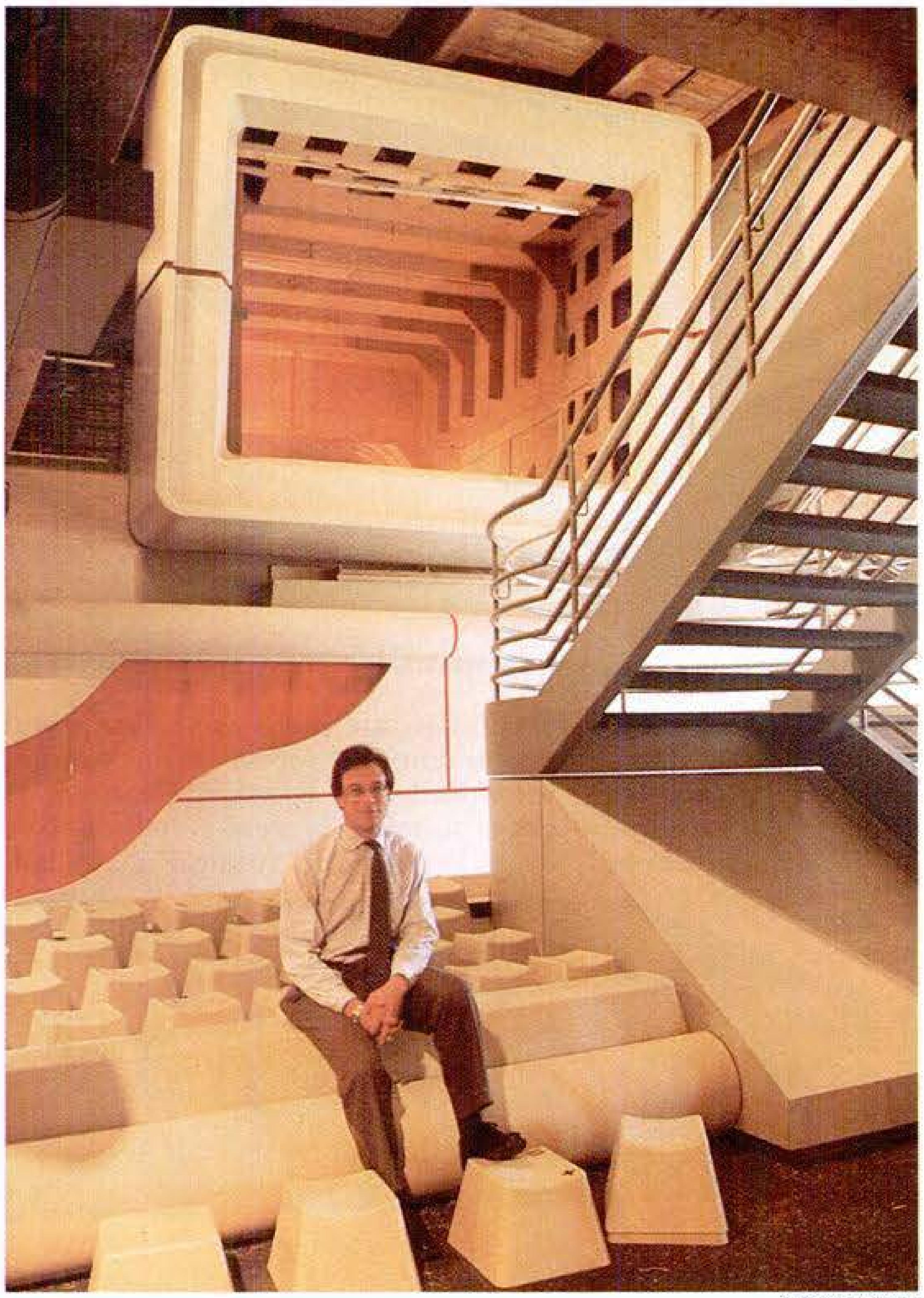


◀ Fix-it robot

When the space station Freedom needs repair or maintenance, the anthropomorphic Flight Telerobotic Servicer robot will be there to do the job. This prototype titanium "hand" will have two exchangeable "fingers" enabling the FTS to grasp, turn a screw, and perform other functions as needed. Two motors allow it to squeeze and rotate. The device was created by Honeybee Robotics of New York with Ford Aerospace of Palo Alto, Calif. NASA officials plan to test it in 1991 aboard the space shuttle.

◀ Escape route

The Exit Traveler is designed to get you out of burning buildings quickly. The fireproof steel cable will lower you to the ground at a controlled rate of 18 inches per second. The 10-by-6-inch unit is available in 4-, 7-, and 12-story models. R.A.W. Rescue Products, Box 314, Ambler, Pa. 19002-0314. Price: $398.



RICHARD FOWLER

Two-story computer ▲

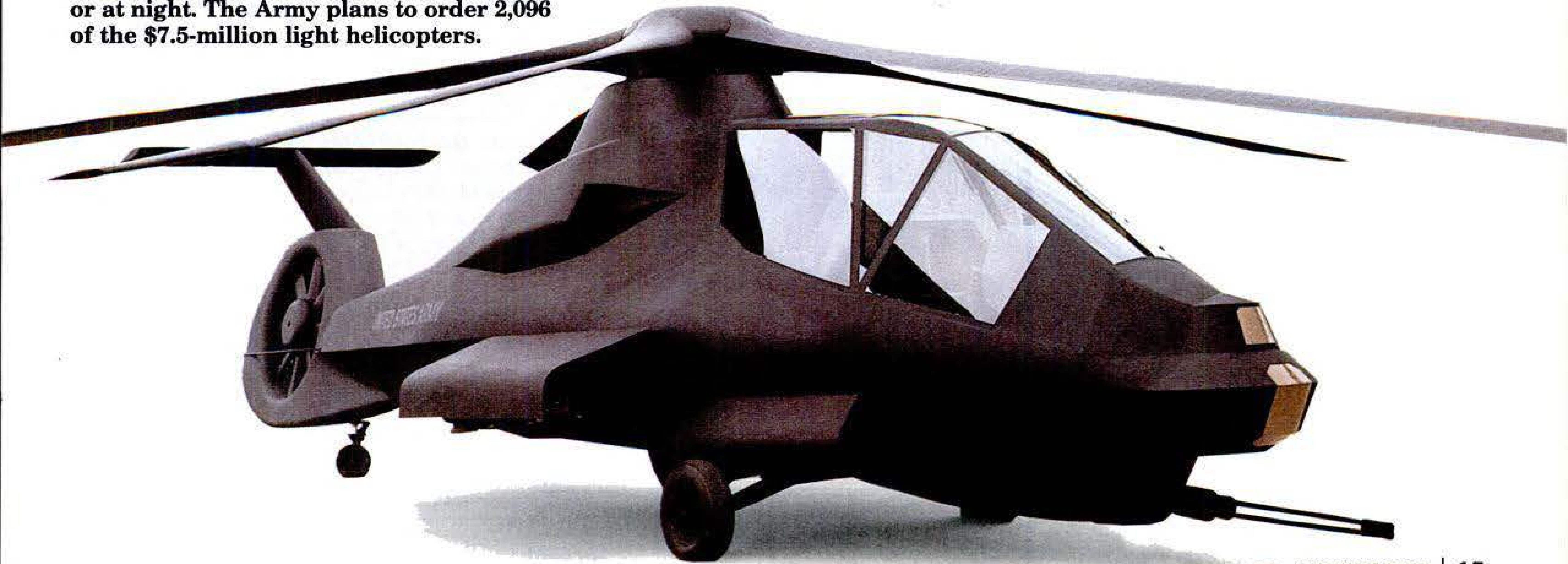
Fifty times larger than life, the Walk-Through Computer gives visitors a new perspective of the way a computer works. The computer has a 25-foot-long keyboard, a five-foot-tall track ball, and a 108-square-foot monitor. Created by museum director Dr. Oliver B. R. Strimpel, the exhibit is at The Computer Museum in Boston.

Signed, sealed, and delivered ▲

The A.C.T. ATM lets you pick up airline tickets in minutes, 24 hours a day. Ticket information is sent via phone by your travel agent to the machine, which prints it out after you identify yourself with a credit card. A.C.T. Inc. in Santa Ana, Calif., expects that 5,000 machines will be available in hotel lobbies, office buildings, and grocery stores by 1992.

Chopper mock-up ▼

Boeing and Sikorsky recently revealed a mock-up of their version of the Army's future light helicopter. The chopper will have a complex electro-optical and infrared system to identify targets instantly—even in bad weather or at night. The Army plans to order 2,096 of the $7.5-million light helicopters.



BY WILLIAM J. HAWKINS

What's New ELECTRONICS

Digital camcorder ▶

Sony's Hi8 camcorder captures scenes in its three-megabyte memory. The memory is used for digital noise reduction, jitter removal, and special effects such as strobe, freeze-frame, pictures superimposed over other pictures, and a 2× digital zoom. The CCD-V5000 is $2,700.

Front loader ▲

Like other carousel-type CD changers, the Magnavox CDC552 lets you change any of four discs while the fifth is still playing. But unlike most other changers, which are top-loading machines, the carousel in this new model slides out from a front drawer. That lets you put the player on a shelf or stack other components on top. The price: $300.

Multi-language VCR ▼

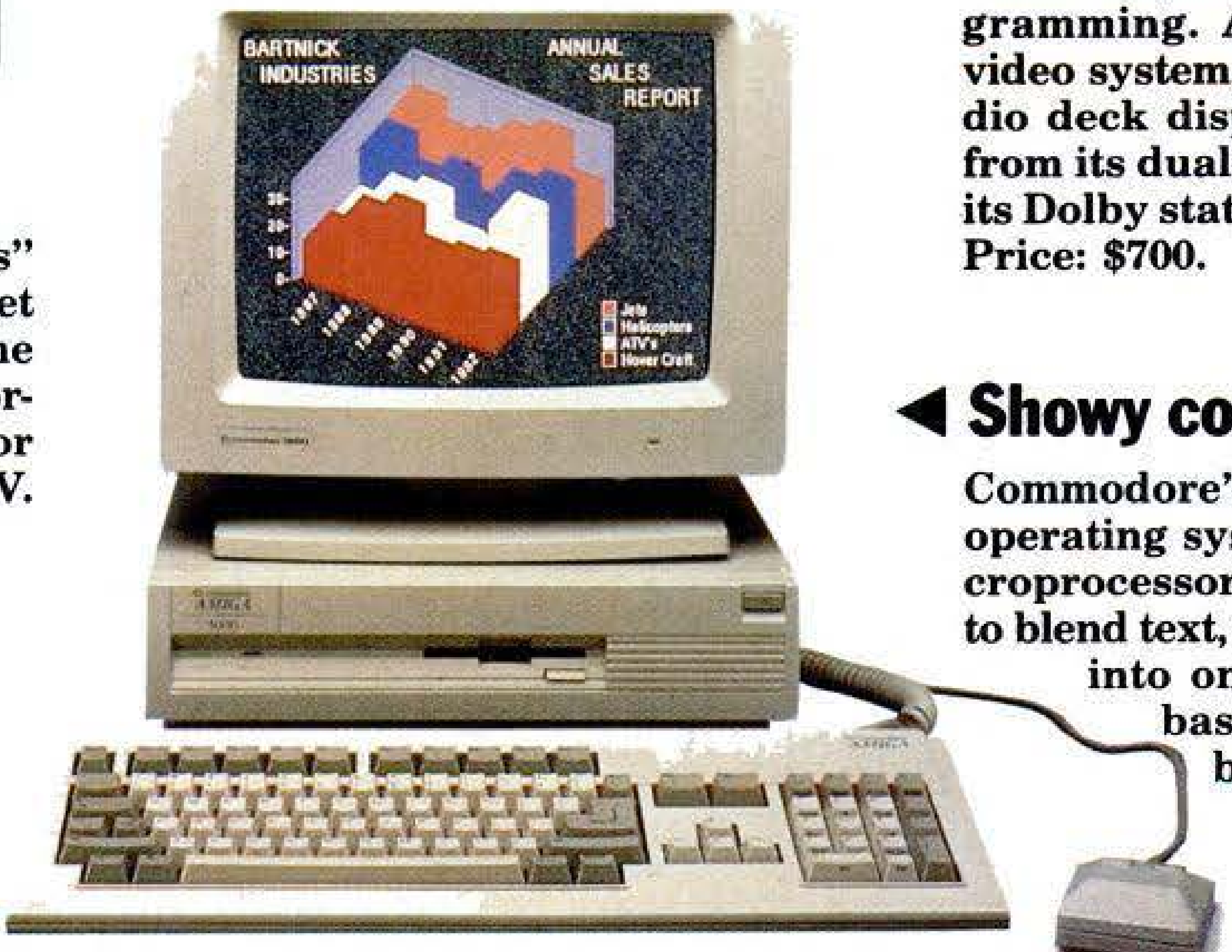
Turn on RCA's new VR341 VCR and it displays setup and programming instructions on your TV screen. What's more, the VCR gives you the information in English, Spanish, or French. An automatic programming system selects active stations in your area from its 181-channel tuner. Price: $349.

Audio deck for TV ▲

It's the first audio cassette deck with a *video* output. Reason: on-screen programming. Attached to your audio-video system, Mitsubishi's M-T5010 audio deck displays all its operations—from its dual-cassette editing modes to its Dolby status—on the video monitor. Price: $700.

Studious TV ▲

As you watch JVC's TV, it "watches" you. Using artificial intelligence, the set monitors your daytime and nighttime viewing habits to determine your favorite shows, then lists them on a menu for reference whenever you turn on the TV. The 32-inch model is about $2,000.



◀ Showy computer

Commodore's Amiga 3000 uses a new operating system (2.0) and a 68030 microprocessor with math coprocessors to blend text, graphics, audio, and video into one "multimedia" PC. The basic system has two megabytes of memory; $3,300.

Tune up your dashboard at the Kmart Auto Sound Sale.

399.97 **Everyday Low Price.**
Sparkomatic SR600 AM/FM Compact Disc Player with Synthesizer Tuner. 3-beam laser pickup, 12 FM and 6 AM presets, scan and standby controls, and 25-watt output.

Sparkomatic

69.00 **Your Choice.**

Kraco KPA100 100-Watt Amplifier. 50 watts per channel, 3-way input compatible for high level, low level and high power. Automatic remote activation.

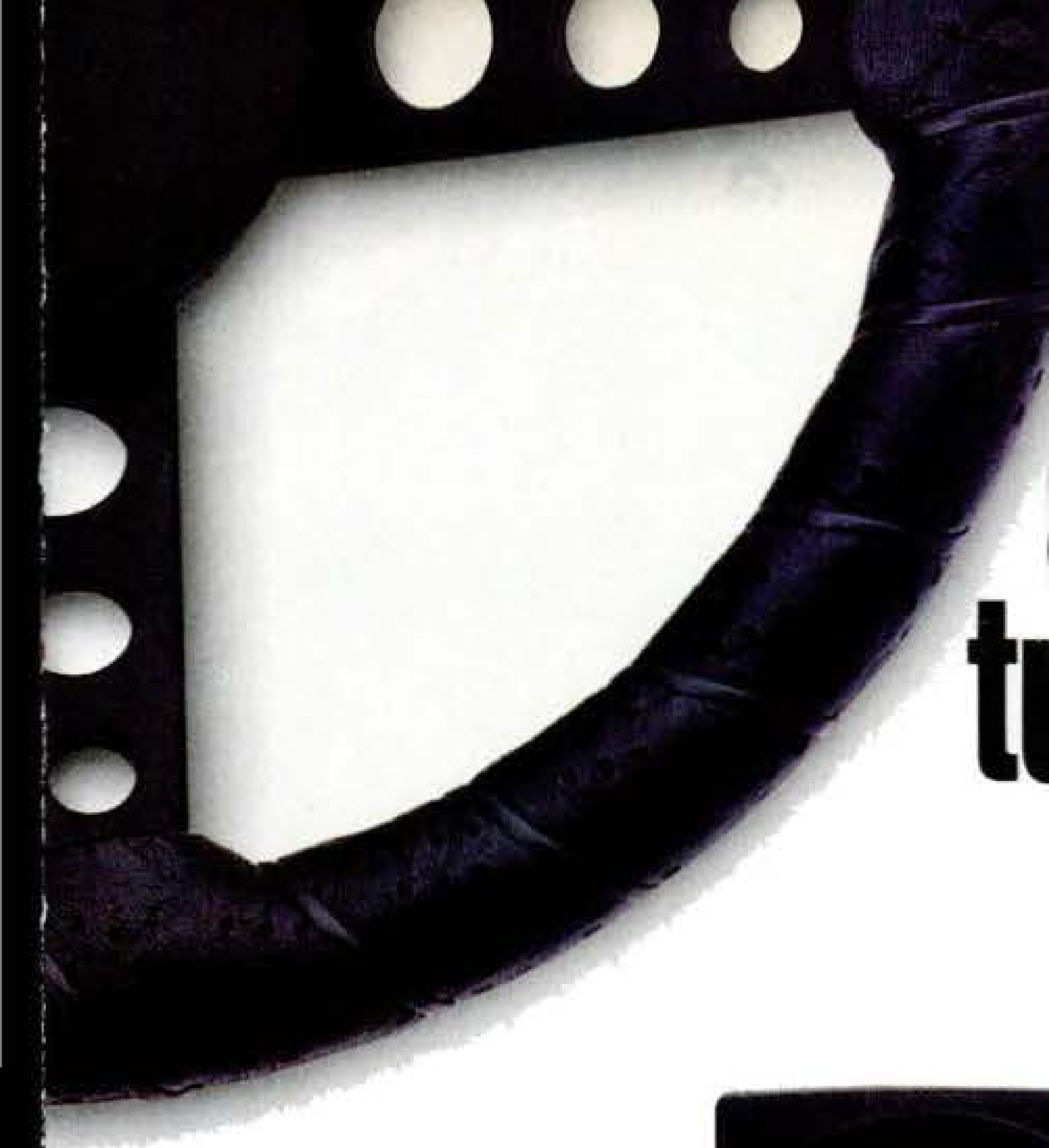
Kraco

Pioneer TS6933 2-Way Speakers. 6″ x 9″ Maxxial® 100 watts maximum.

Pioneer

The quality you need, the price you want.

Kmart
the Saving Place



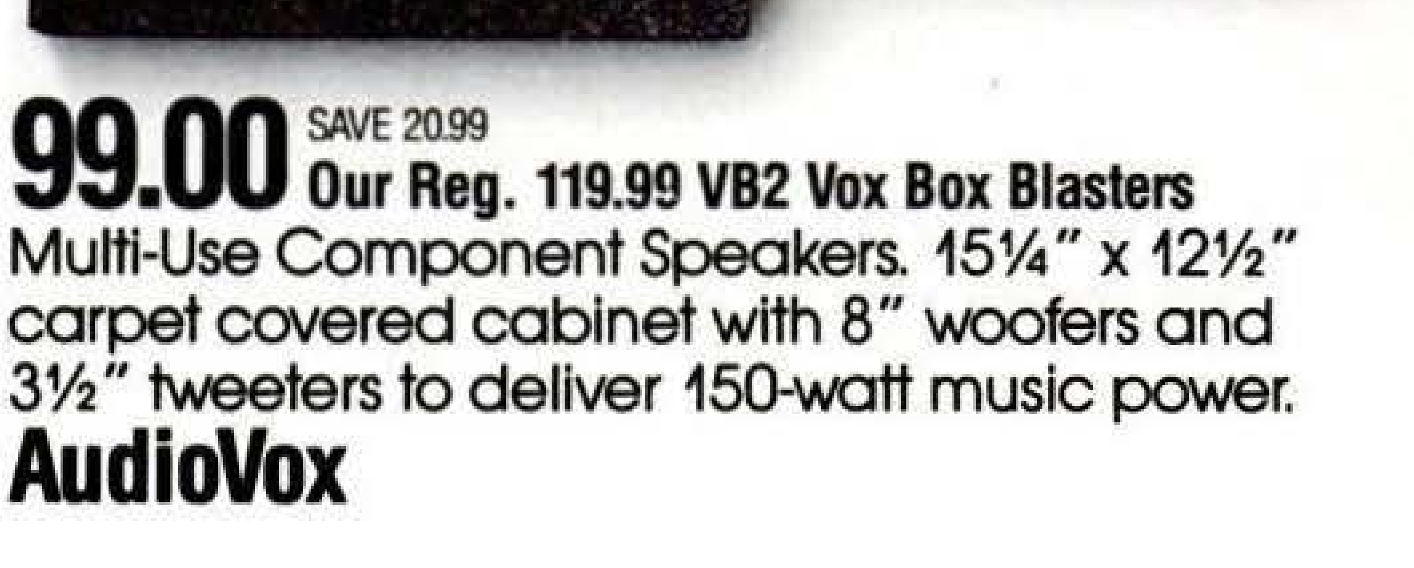
Turn up the volume at prices you can't turn down.

79.00 SAVE 20.97 **Our Reg. 99.97 Kraco KMP600 AM/FM Stereo Cassette with Speakers.** Digital display, 3-band graphic equalizer and 40-watt power booster. Includes one pair 6" x 9" coaxial speakers.

Kraco

49.00 SAVE 20.97 **Our Reg. 69.97 Sparkomatic C45BP AM/FM Cassette Stereo with 5¼" Dual-Cone Speakers.** Car stereo featuring locking fast forward, and tone and balance control.

Sparkomatic



99.00 SAVE 20.99 **Our Reg. 119.99 VB2 Vox Box Blasters** Multi-Use Component Speakers. 15¼" x 12½" carpet covered cabinet with 8" woofers and 3½" tweeters to deliver 150-watt music power.

AudioVox

64.00 SAVE 15.97 **Our Reg. 79.97 Sparkomatic 9440 3-Way Surface-Mount Speakers** with dome mid-range tweeters and ¾" woofers for accurate bass response.

Sparkomatic

99.00 SAVE 15.97 **New! Our Reg. 114.97 AudioVox AV952 AM/FM Stereo Cassette.** Electronically tuned stereo with station memory, seek tuning, and locking fast forward.

AudioVox

159.00 SAVE 30.97 **Our Reg. 189.97 Pioneer KE2022 In-Dash Deluxe ETR AM/FM Stereo Cassette** with auto-reverse, 15-station preset, locking fast forward and rewind, and liquid crystal display.

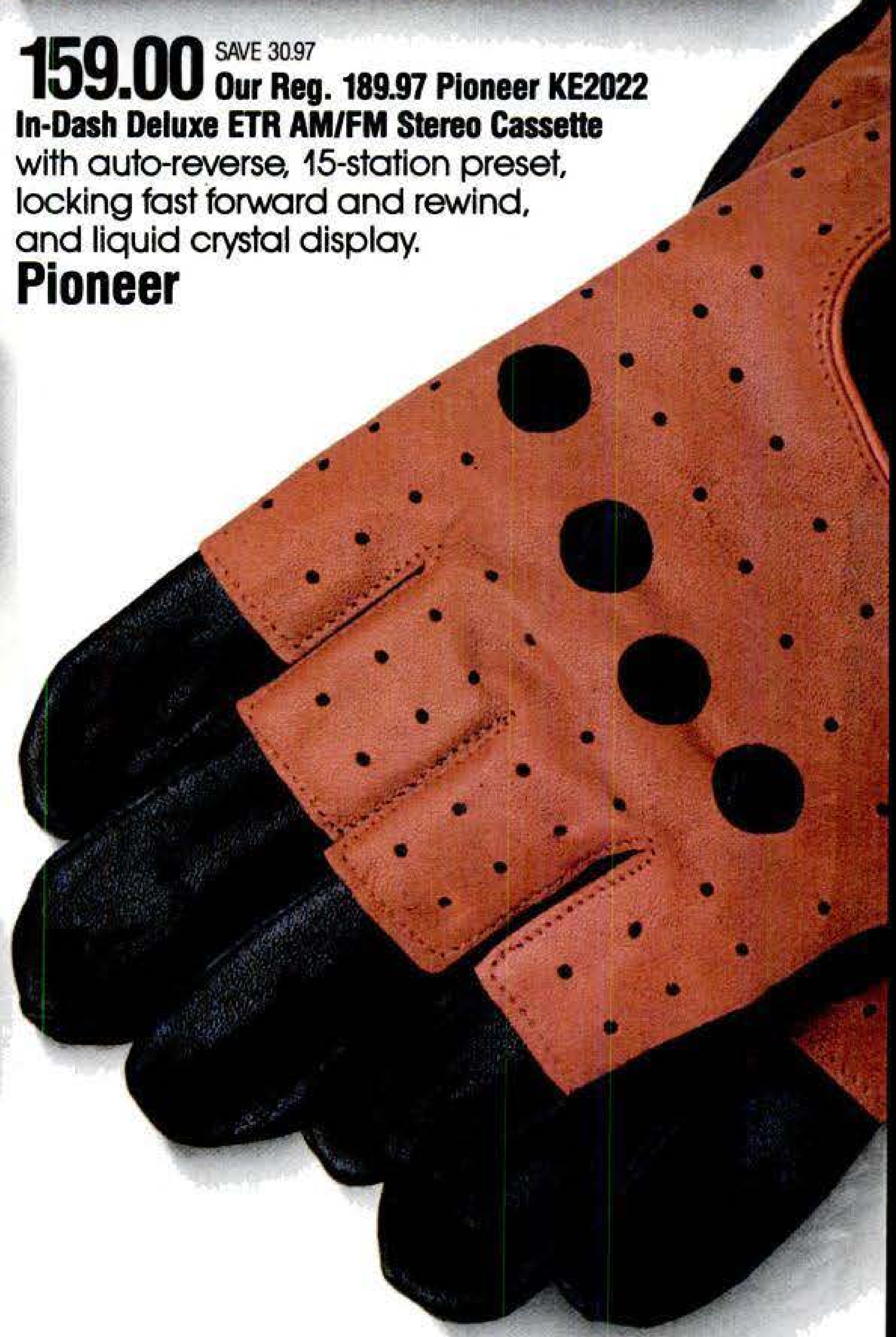
Pioneer

149.00 SAVE 20.97 **Our Reg. 169.97 Sony ESR11 AM/FM Auto-Reverse Cassette Stereo** with seek and preset quartz tuning.

Sony

129.00 SAVE 20.97 **Our Reg. 149.97 Jensen CS4500 AM/FM Cassette Stereo** with auto-reverse, seek, fader, 12 FM and 6 AM presets, and automatic program control.

Jensen



69.00 SAVE 20.97 **Our Reg. 89.97 Sparkomatic SR338 Electronically Tuned AM/FM Cassette Stereo** with programmable station memory and seek function.

Sparkomatic

49.00 SAVE 15.97 **Our Reg. 64.97 AudioVox AMP785 50-Watt Graphic Equalizer/Amplifier** with dual power meters, built-in fader and seven frequency controls.

AudioVox

The quality you need, the price you want. Kmart the Saving Place

K mart Auto Sound Sale. Complete with bells and whistles.

***149.00** SAVE 40.97 **Our Reg. 189.97 Whistler WH750 Deluxe Radar Detector.** Compact full-feature detector with highway/city mode switch, pulse protection, 5-segment LED array and advanced selectivity system.

Whistler

*Not available in CT and VA.

***59.00** SAVE 20.00 **Our Reg. 79.00 Whistler WH225 Radar Detector.** 3-segment LED array, monitors both K and X bands, highway/city mode switch, one-year warranty.

Whistler

*Not available in CT and VA.

24.00 Your Choice.

AudioVox AMP760 Graphic Equalizer or Sparkomatic SK693 6" x 9" Speakers. Not shown: Kraco THP3 3½" Speakers or Sparkomatic SK63 6" Speakers.

Sparkomatic / AudioVox / Kraco

49.00 Your Choice.

Cobra C39 Plus Emergency CB with Magnet-Mount Antenna, **or C20 40-Channel CB.**

Cobra

On sale July 29 through August 11, 1990, at most K mart stores across the U.S.A.

K mart ADVERTISED MERCHANDISE POLICY

Our firm intention is to have every advertised item in stock on our shelves. If an advertised price is not available for purchase due to any unforeseen reason, K mart will issue a Rain Check on request for the merchandise (one item or reasonable family quantity) to be purchased at the sale price whenever available or will sell you a comparable quality item at a comparable reduction in price.

The quality you need, the price you want.

Kmart the Saving Place

BY ARTHUR FISHER

What's New PHOTOGRAPHY

Auto composer ▶

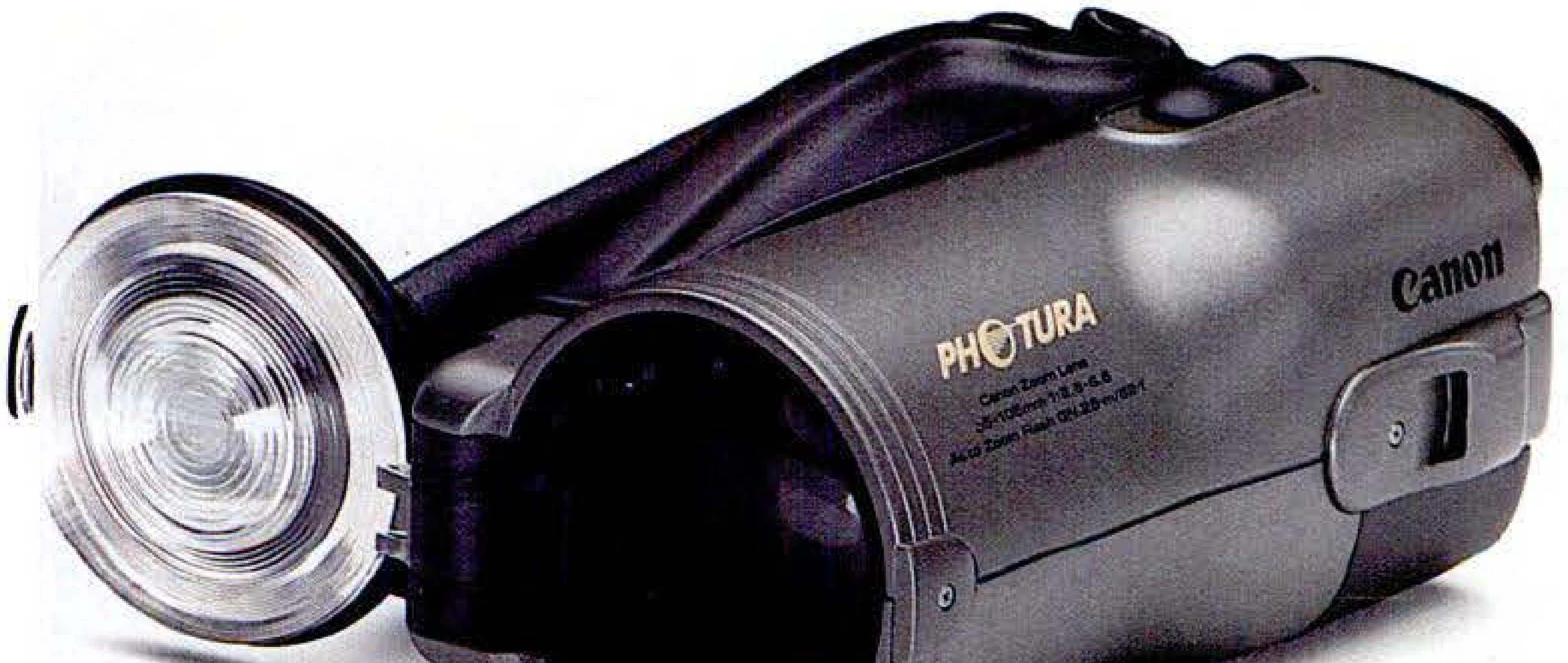
The third generation of Chinon's hybrid, or "bridge," cameras is the Genesis III. Its microcomputer-controlled macro lens zooms from 38mm to 110mm. The most unusual feature is a multibeam picture composition system that is linked to the zoom lens. The photographer preselects the type of composition desired, and the camera automatically controls zoom and exposure. Suggested list is $699.

Compact auto everything ▲

Apart from the usual complement of automatic features, Samsung's AF Zoom 700 even turns itself off if no pictures have been made after a decent interval. It comes with an f/3.5-6.7 35mm to 70mm lens. There are three flash settings: auto, fill-in, and off. The price is $390.

◀ Stretched zoom

Pentax continues to stretch the reach of the IQ point-and-shoot models. This one zooms from 38mm to 105mm. There are both a macro and a super macro setting, allowing close-ups at 1½ feet.



◀ New-look 35

With a radically different look, the cylindrical Canon Photura capitalizes on the compact nature of integral lens/shutter designs. The f/2.8-6.6 lens zooms from 35mm to 105mm; there are both an eye-level and a low-angle viewfinder, and the flash (which also zooms) is in the lens cap. Price: about $500.

Wide-ranging zoom lens ▶

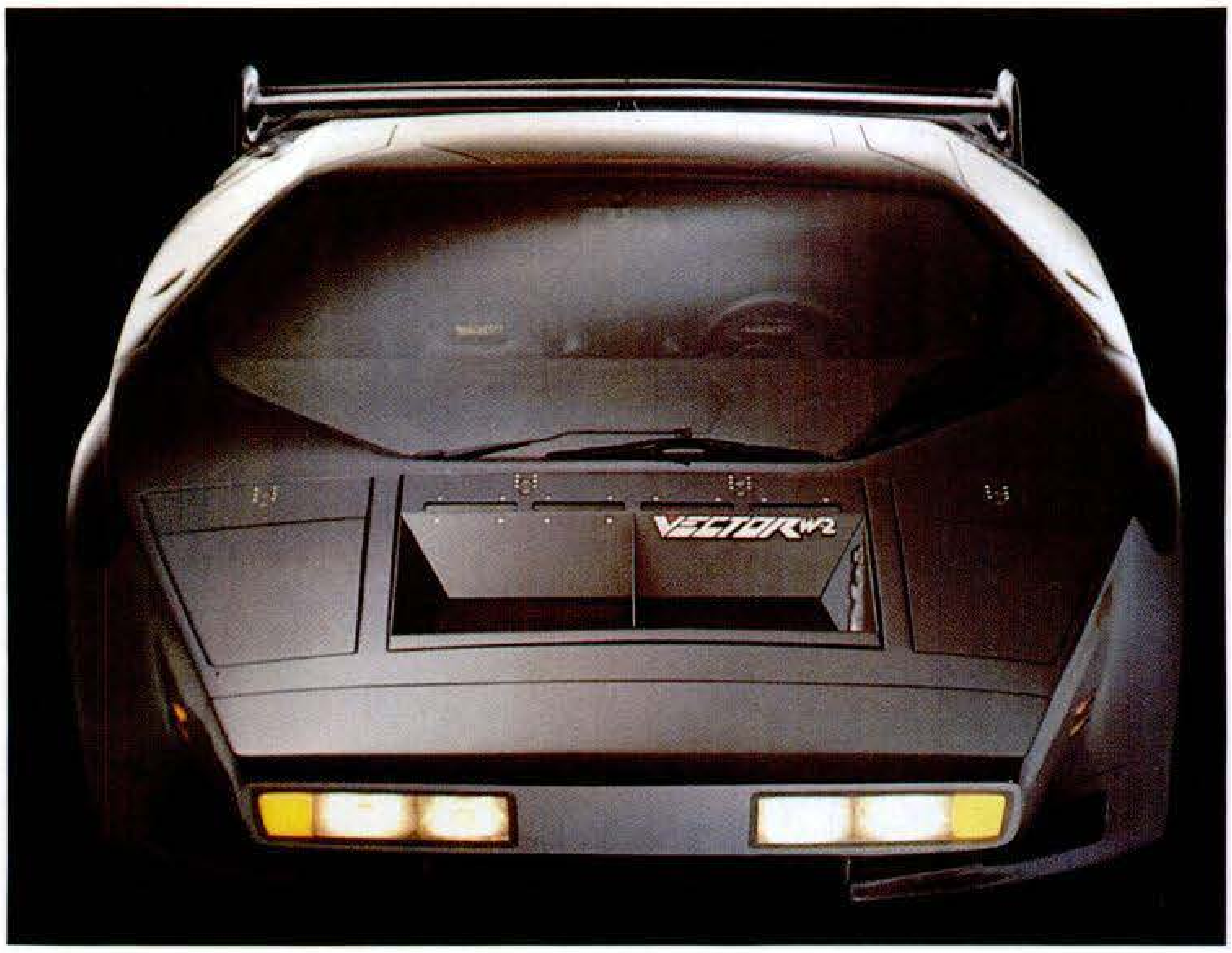
This f/3.5-5.6 macro zoom lens from Ricoh provides an unusually large zoom range: 28mm to 200mm, or 7.1×. Yet it is relatively compact and lightweight, measuring 4½ inches long and weighing 18 ounces. The macro mode allows one-fourth life-size photos. The suggested list price is $369.

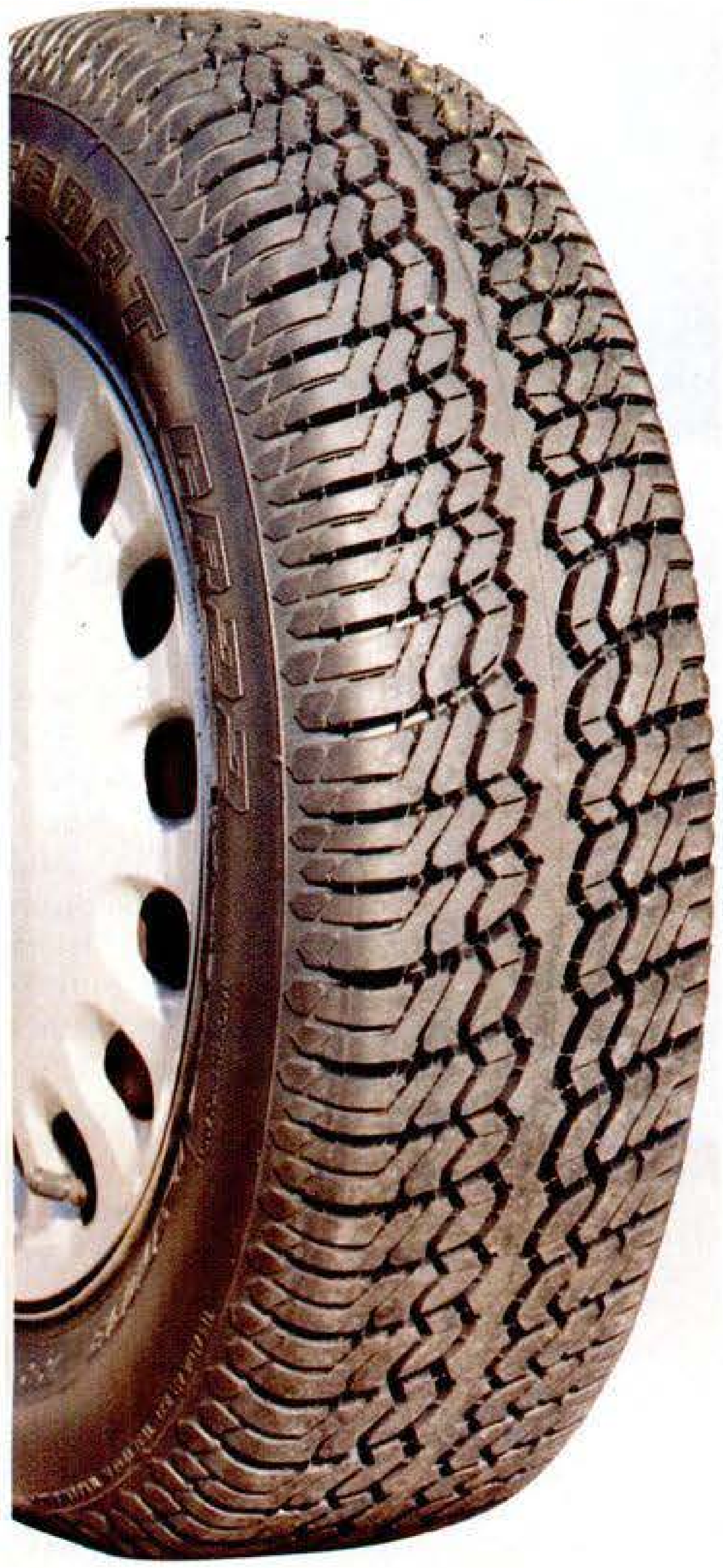
BY BRIAN NADEL

What's New AUTOMOTIVE

American exotic ▶

The Vector, a $250,000 two-seater, is powered by a twin turbocharged six-liter aluminum V8 capable of at least 600 hp; top speed is over 200 mph, and it can accelerate to 60 mph in four seconds, says the designer and builder, Vector Aeromotive Corp. (400 N. Marine Ave., Wilmington, Calif. 90744).





Tire for the wet ▲

The advanced computer-designed tread on the Avon Turbosport CR22 tire gives exceptional grip, cornering power, and short stopping distances in the rain, says its maker. Key to this performance is its ability to pump water away from the tread. Avon Tyres Ltd., Melksham, Wiltshire SN12 8AA, England.

◀ Scratch-hiding sealer

Spectracote polymer-based sealer contains color pigments to cover small nicks and scratches in a car's finish, according to the manufacturer. Available in 10 colors, the product is rubbed directly onto the damaged area and blends in with existing wax or sealer. Spectracote costs $10 for a 16-ounce bottle. Heathwood Chemical Corp., Box 68, Williamsville, N.Y. 14231-0068.

Instant alarm ▶

The Foxguard I portable car alarm has many of the features of high-priced custom-designed alarms, but at $100 it is affordable and easy to install. The alarm is powered by the vehicle's cigarette-lighter outlet and sounds a 110-decibel siren. A personalized three-digit code arms and disarms the device. Fox Marketing, 1747 Cattleman Rd., Sarasota, Fla. 34232.

Today's Spider ▶

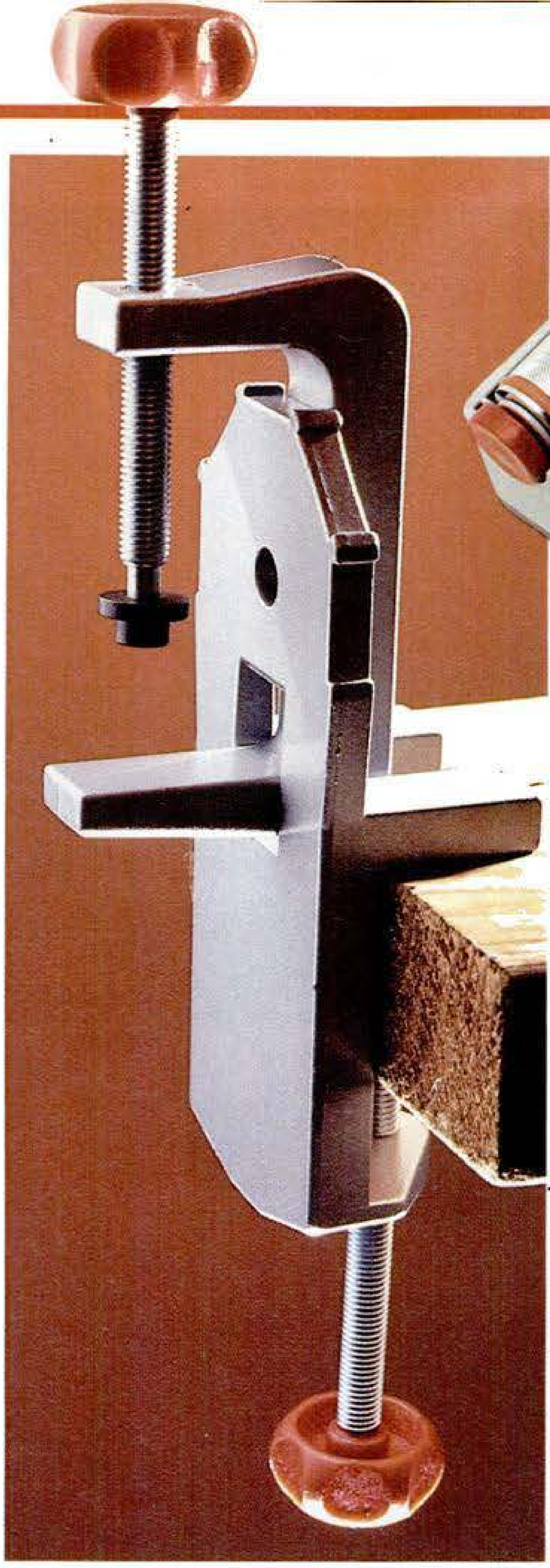
Alfa Romeo updates its classic rag-top Spider with a slimmer look, integrated bumpers, and more power. The double-overhead-cam two-liter power plant develops 120 hp. The Veloce model shown is $22,950, plus $2,500 for the removable hardtop. The base Spider costs $20,950.

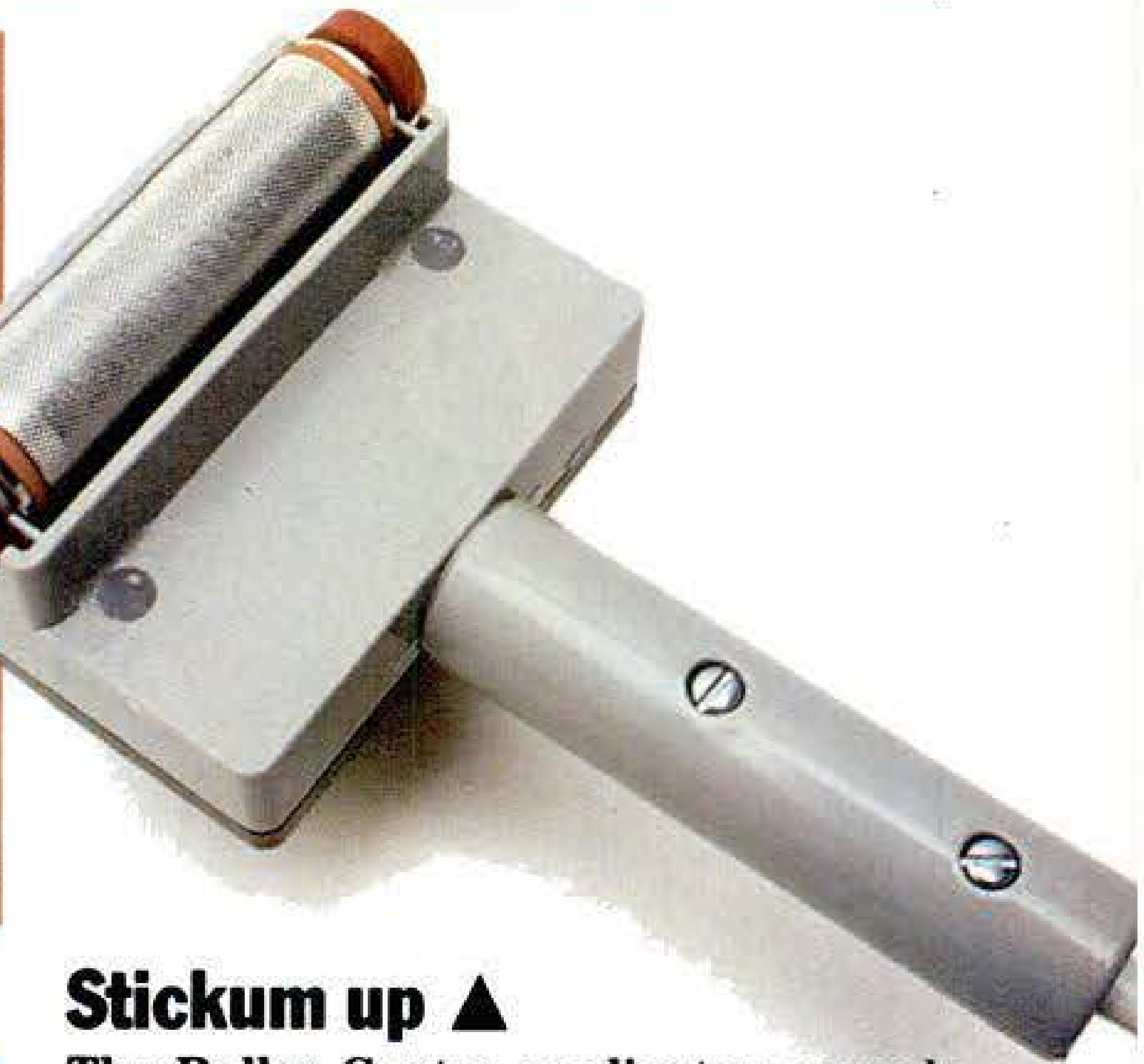
BY MARIETTE DiCHRISTINA

What's New TOOLS

Helpful hang-ups ▲

Finally organizing the garage? Super Clip can help. The beads on its flexible polyurethane strap snap into a socket to hold shovels, brooms, pipes, and more securely; pull the strap to release. Available in eight colors, the polyethylene clip costs $2.89. Rowland Products International, 497 11th St., Suite 12, Imperial Beach, Calif. 92032.





Stickum up ▲

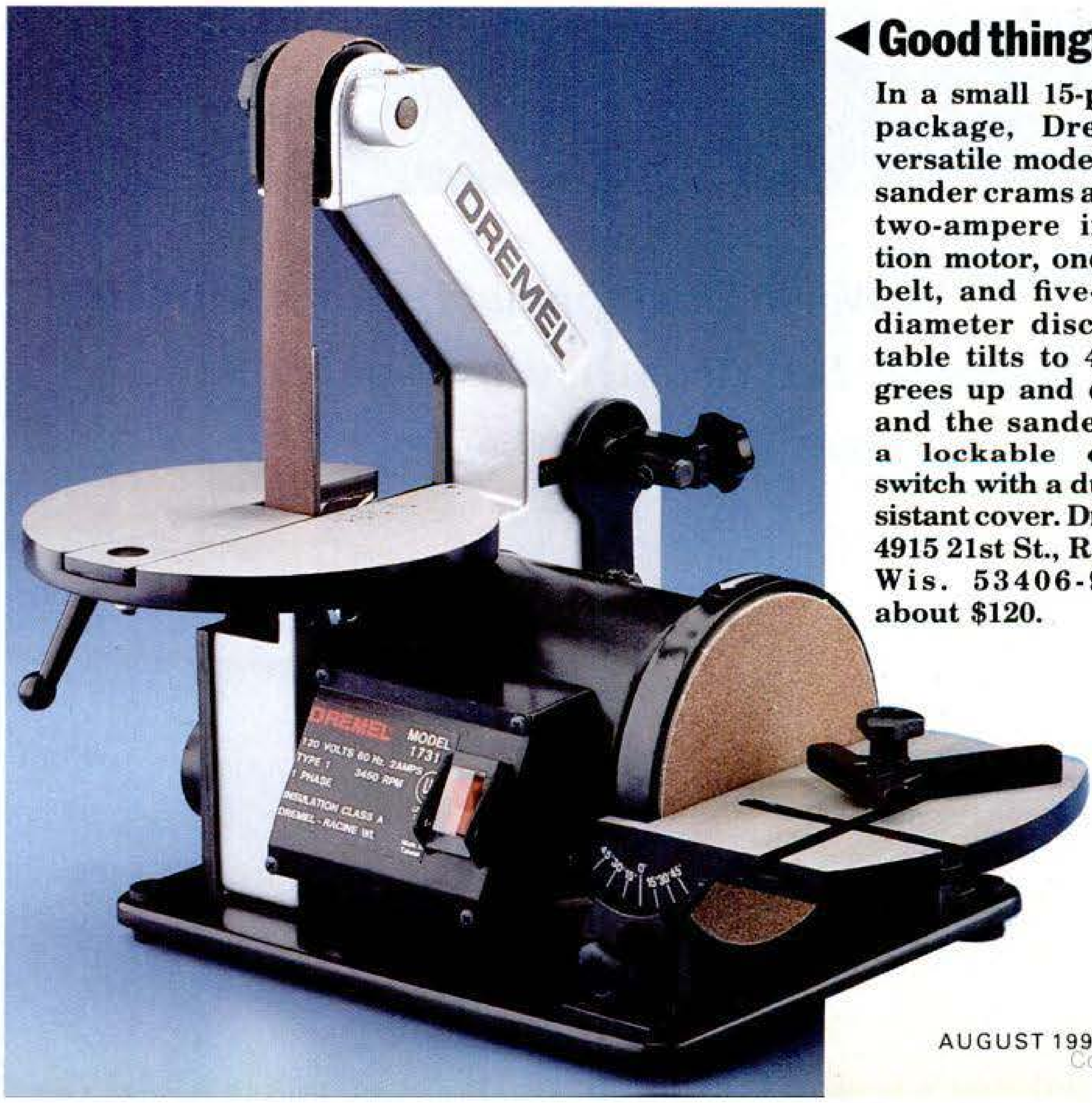
The Roller Coater applicator spreads a three-inch-wide strip of an unusual hot-melt adhesive: It sets instantly but remains tacky permanently. You can then affix the sticky item to almost anything, says Martin R. Carbone, Inc. (2519 Bath St., Santa Barbara, Calif. 93105). Roller Coater and ¼ pound of adhesive (enough to cover 25 square feet) cost $125. A five-pound box of adhesive costs $30.

◀ Clever clamp

Attach the base of the die-cast-aluminum 12-in-1 Woodworker's Board Clamp to bench tops up to two inches thick. Then you can arrange its C-clamplike jaw to hold your work in any one of six ways—on or off the bench. The jaw accommodates pieces up to 2½ inches thick and any width or length. Cost: $10. Leichtung Work Shops, 4944 Commerce Pkwy., Cleveland, Ohio 44128.

Better trimmer ▲

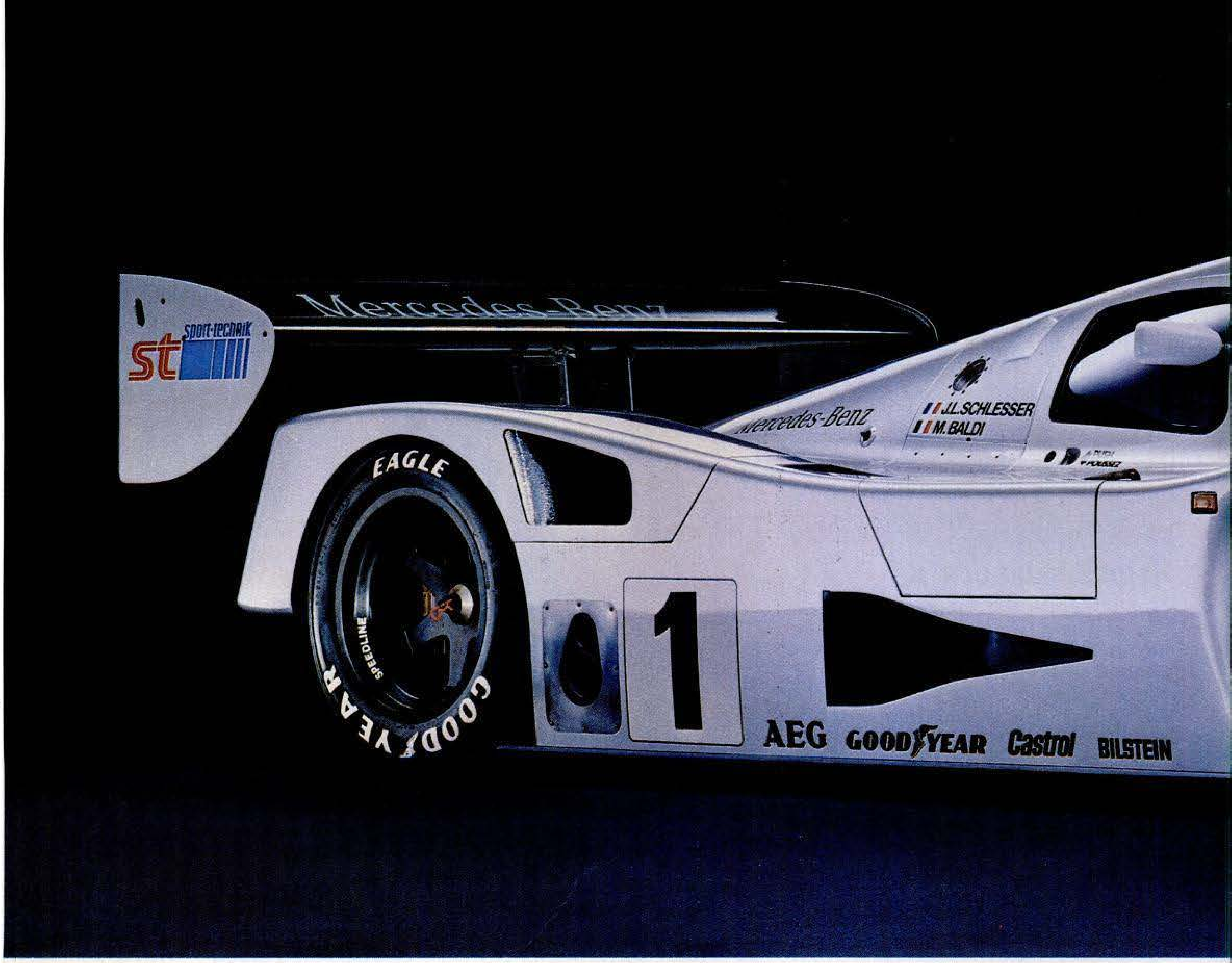
Shave plywood edge banding to the exact width you need with a squeeze and a single stroke using the Double Edge Trimmer, claims The Woodworkers' Store (21801 Industrial Blvd., Rogers, Minn. 55374-9514). The trimmer costs about $20 and adjusts within a range of 9/16 to 1¼ inches.



◀ Good things . . .

In a small 15-pound package, Dremel's versatile model 1731 sander crams a ⅕-hp two-ampere induction motor, one-inch belt, and five-inch-diameter disc. The table tilts to 45 degrees up and down, and the sander has a lockable on-off switch with a dust-resistant cover. Dremel, 4915 21st St., Racine, Wis. 53406-9989; about $120.

ONLY ON



The World Championship-winning Mercedes-Benz team now uses only one make of tires: Goodyear Eagles.

A Goodyear Eagle "contact patch." Where an Eagle demonstrates its superiority.

Mercedes-Benz is known throughout the world for quality, technical innovation and engineering brilliance.

Nowhere are all of those qualities more apparent than in the highly exotic and very sophisticated Championship-winning Mercedes-Benz race cars.

These are the cars that, in 1989, won seven of the eight endurance races that constitute the FIA

World Sports-Prototype Championship.

These are the cars that set new records at the 1989 running of the 24 Hours of LeMans.

In spite of these successes, these cars have now, in 1990, changed to Goodyear Eagle racing radials.

And are pursuing the 1990 World Championship on Goodyear Eagle racing radials. Exclusively.

To meet the demands of Mercedes-Benz newest and fastest racing cars takes very special tires.

Built to perform at the outer edges of tire technology, these tires are designed with a knowledge, experience and skill that no other tire company possesses.

That knowledge, together with our selection for world-beating cars like the Mercedes-Benz C11, are just two of the reasons why we say:

The best tires in the world have Goodyear written all over them.

GOODYEAR

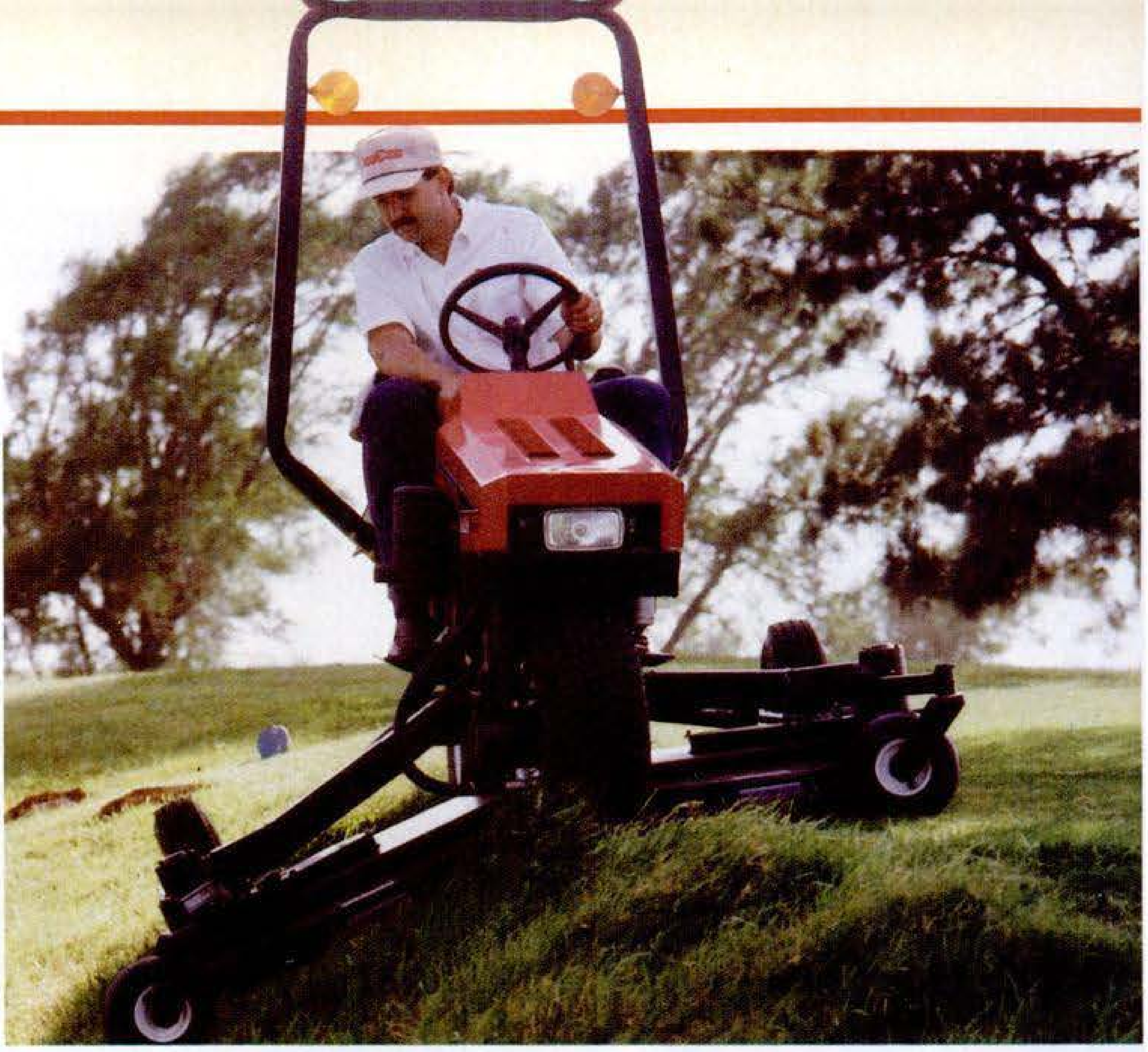
The best tires in the world
have Goodyear written all over them.

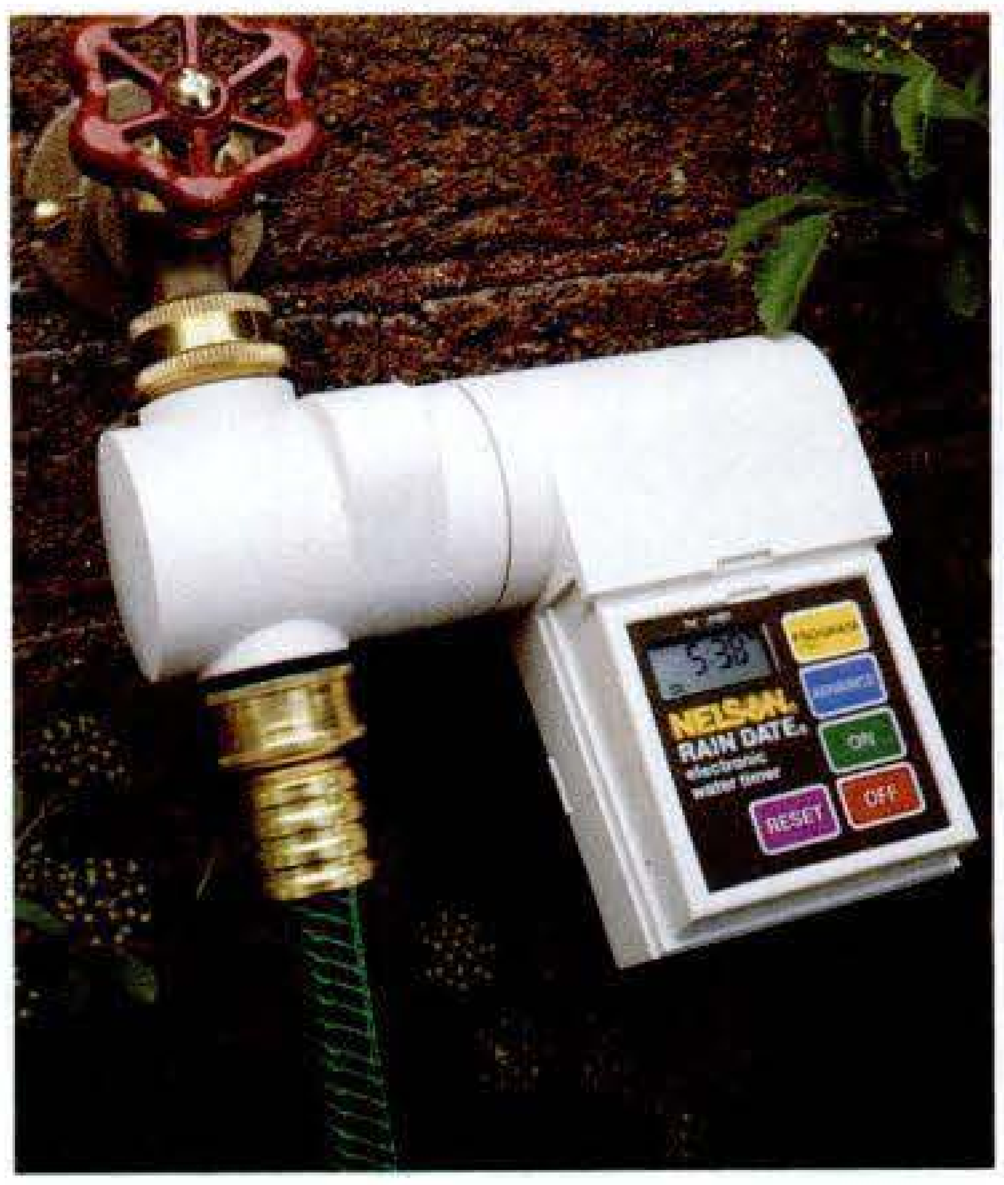
BY TIMOTHY O. BAKKE

What's New OUTDOOR TOOLS

Slope-adapting mower ▶

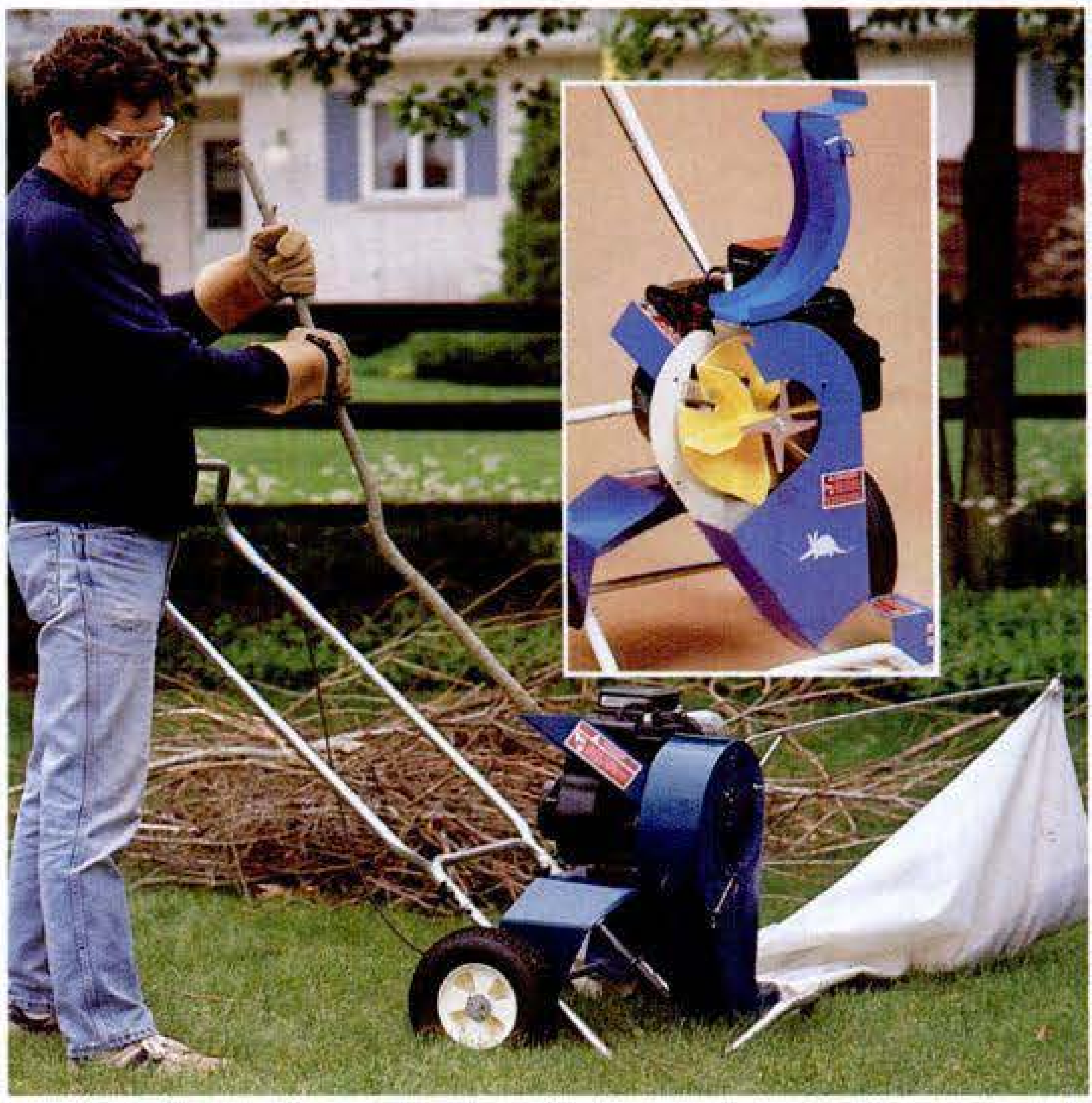
Two powered wheels positioned in tandem, like a motorcycle's, set the 20-hp MC70 riding mower apart from others. But that's not all. Two 36-inch cutter decks are hinged so you can cut the crown of a slope or a V-ditch without scalping the turf. DewEze Manufacturing, Route 2, Box 78, Harper, Kan. 67058.





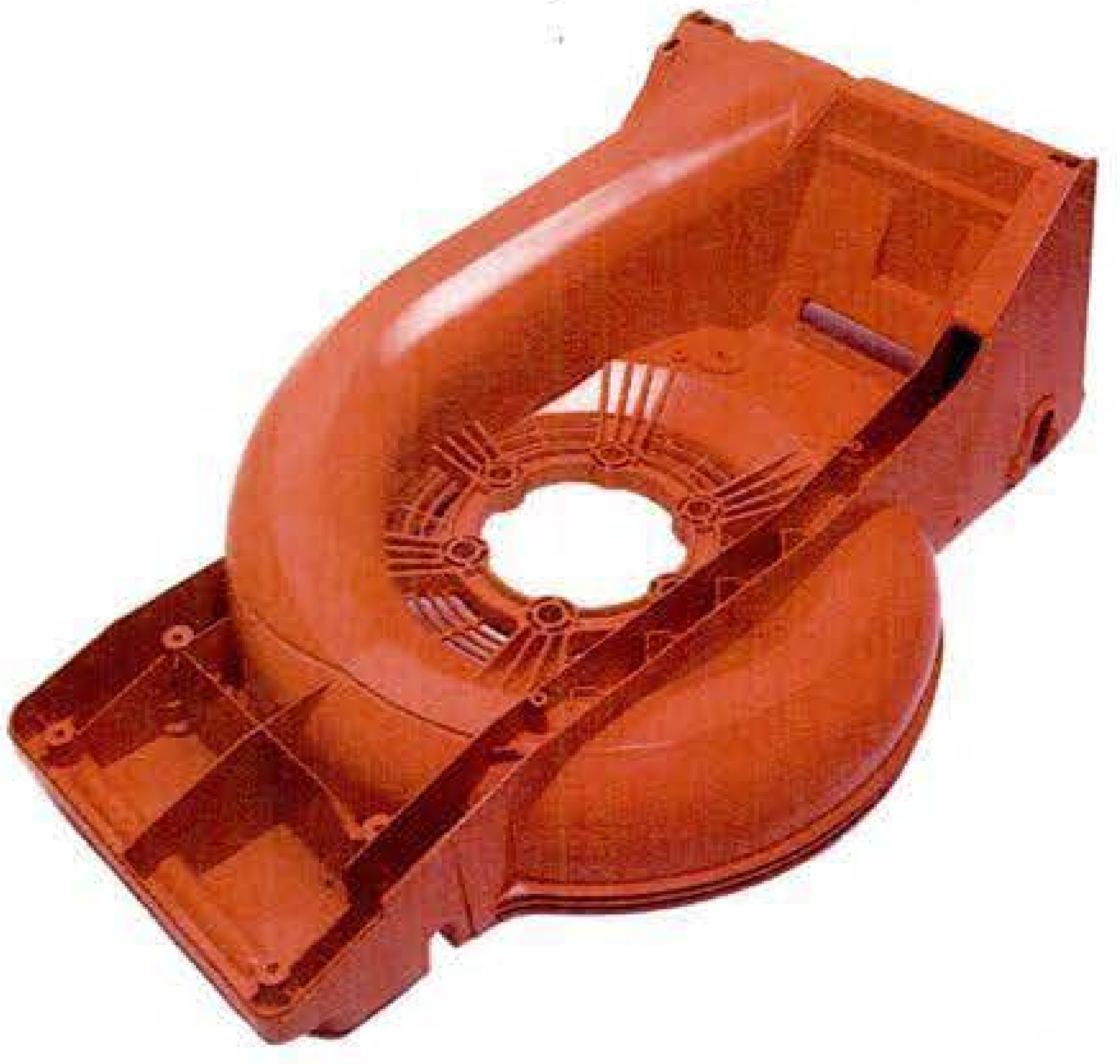
Easy-to-use water timer ▲

Rotate the Rain Date water timer's keyboard unit a quarter-turn and pull: The body detaches so you can program it in your hand for three periods per day, from 1 minute to 12 hours. Four AA alkaline batteries power the $55 timer for a season, says L. R. Nelson Corp. (7719 N. Pioneer Lane, Peoria, Ill. 61615).



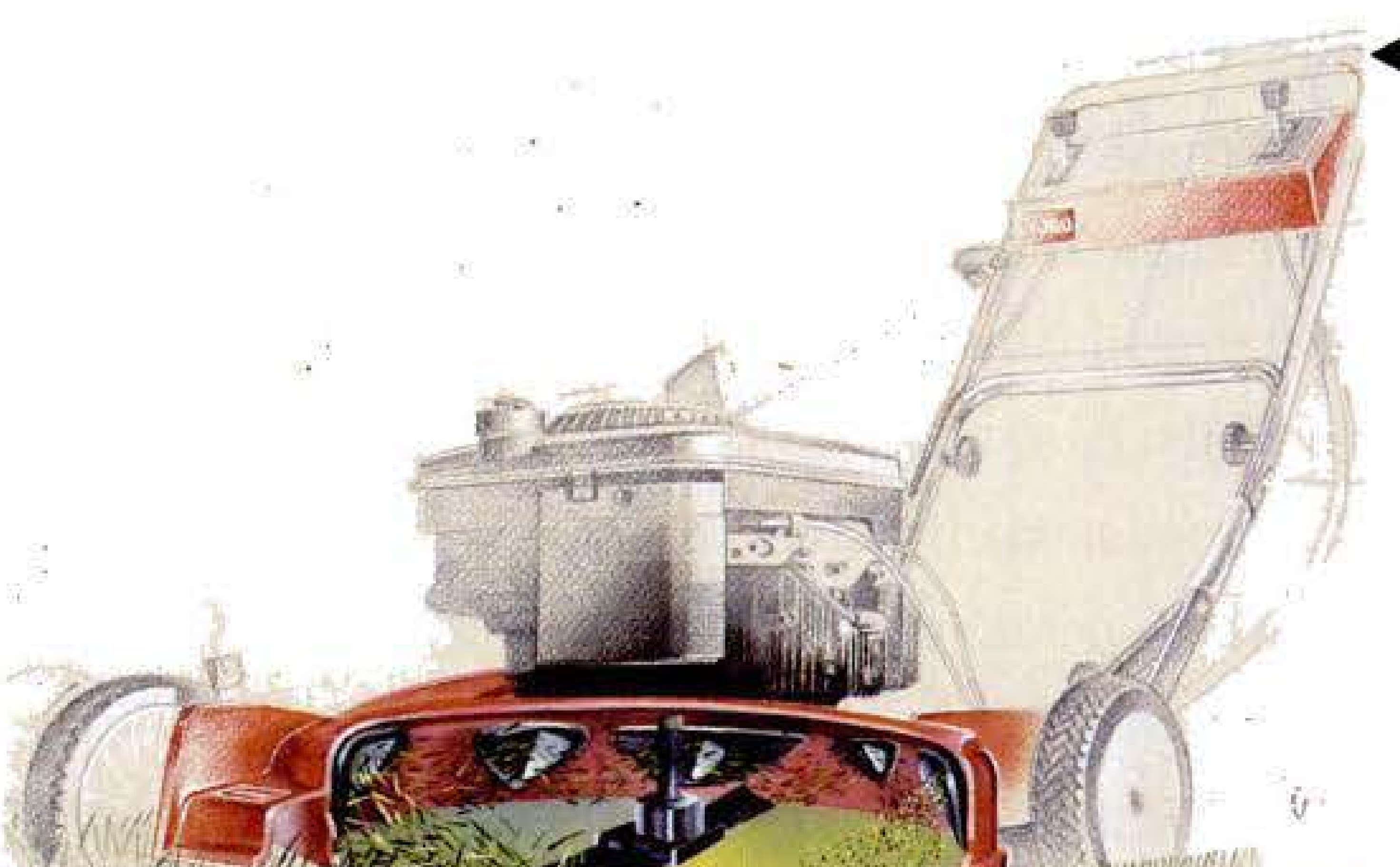
◀4-in-1 recycler

The Yardvark is a three-hp machine that can be converted into four yard tools using various attachments. It can be a chipper (shown); a shredder, with a funnel-like hopper; a vacuum, with a seven-foot-long, five-inch diameter hose; and a blower. The inset cutaway shows the large fan in yellow, with the shredding blade in front of the fan and the chipper knife mounted at the rear. Kemp Co., 160 Koser Rd., Lititz, Pa. 17543; $712, including attachments.



Full-size plastic lawn mower ▲

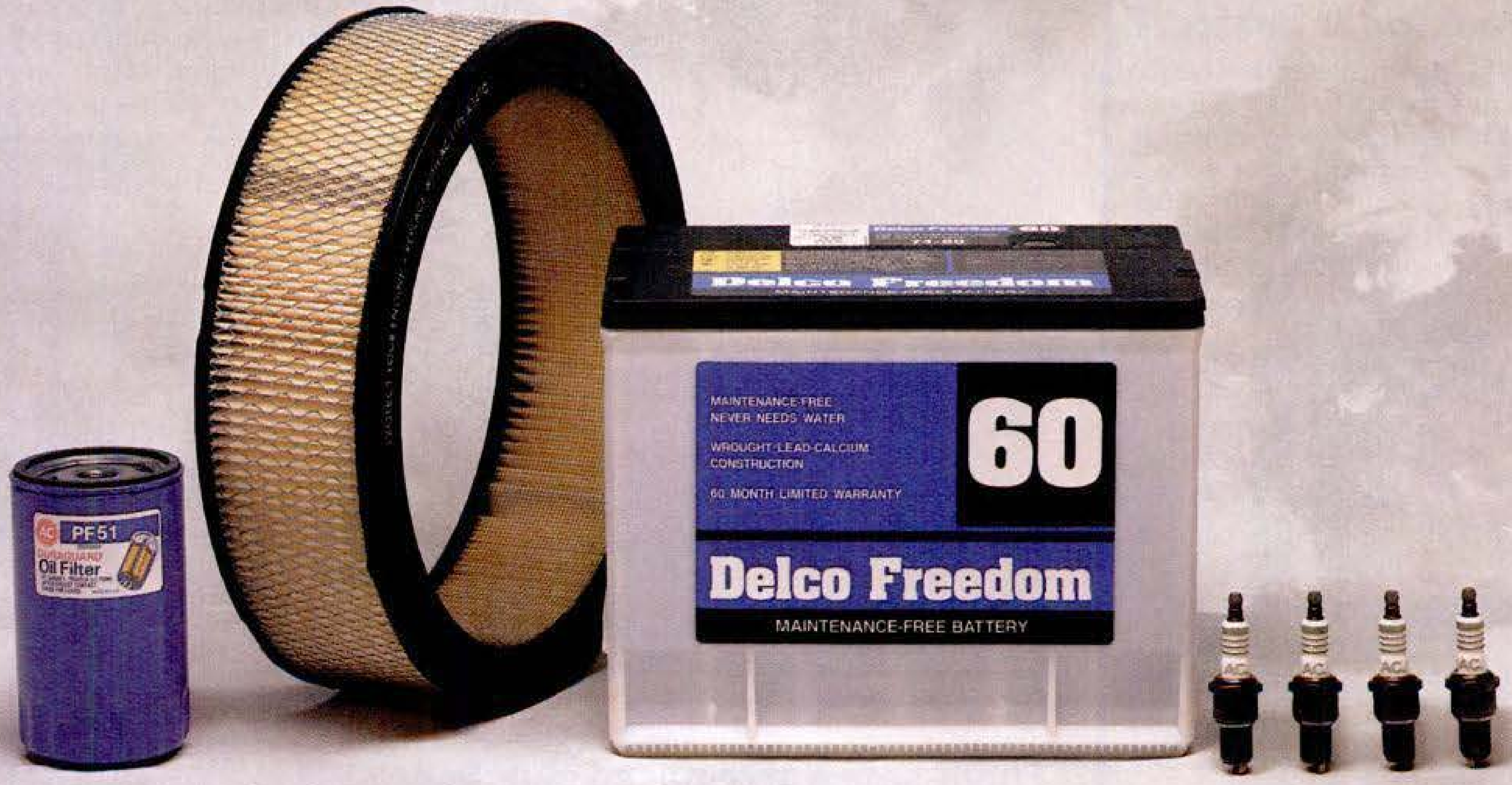
At 21 inches wide, the Royal 53-series mowers are the first full-size units in the United States to have plastic decks, says Husqvarna Forest and Garden Co. (907 W. Irving Park Rd., Itasca, Ill. 60143). Reinforcement ribbing provides engine-mount strength; the ABS plastic does not corrode, says the company.



◀Grass mulcher

With its gull-wing blade and five deflector plates inside the cutting deck (see cutaway), the Recycler lawn mower is able to chop grass fine enough that bagging is not necessary, says Toro Co. (8111 Lyndale Ave. S., Minneapolis, Minn. 55420). Clippings fall between the blades of grass, says Toro, leaving a clean lawn. Price: $399 to $499.

LIFE SUPPORT SYSTEMS

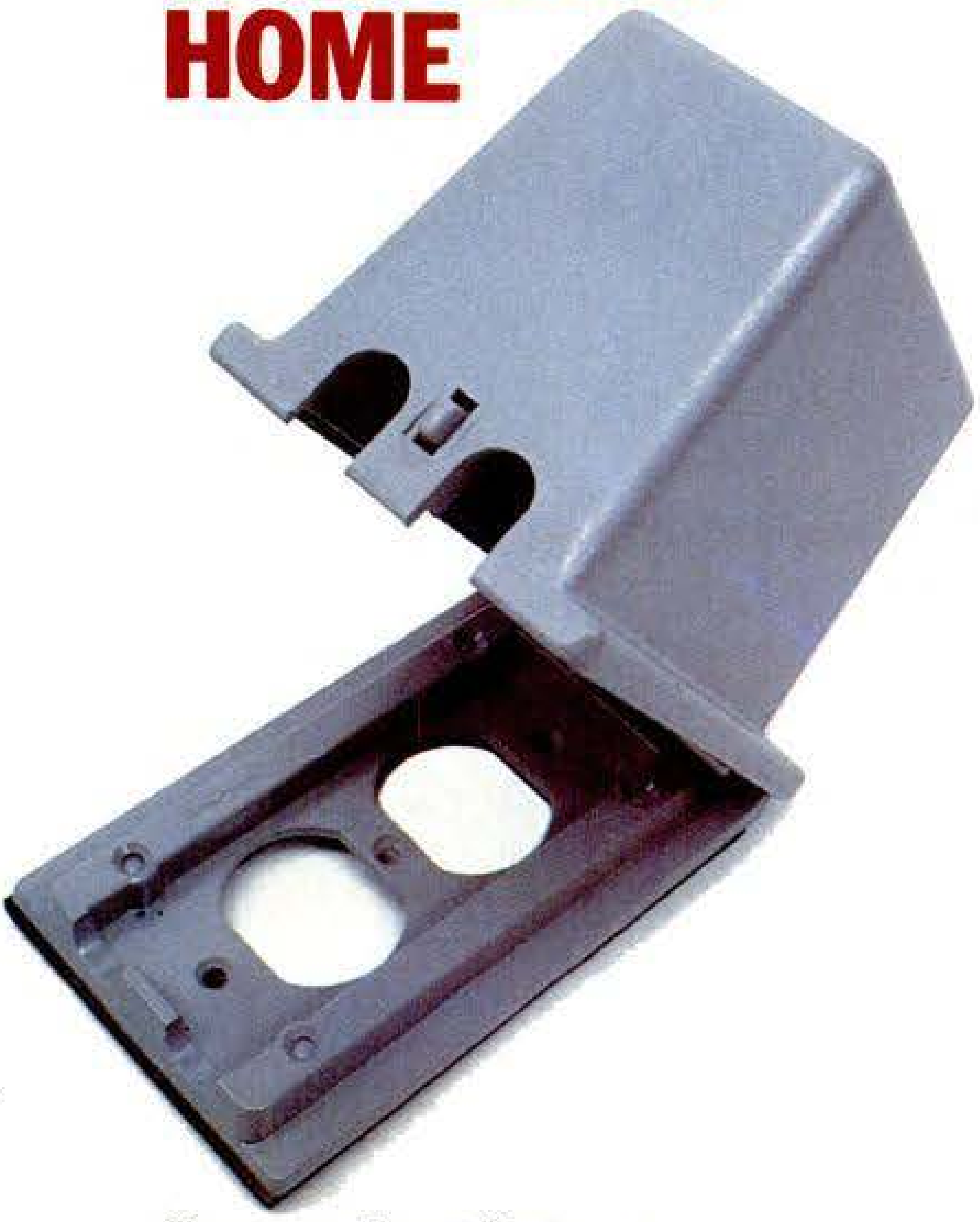


Even if your car isn't ailing now, AC-Delco parts can still help get it started and keep it going. Because all AC-Delco replacement parts are designed to meet the performance and reliability standards a car requires. So make sure yours receives routine checkups and quality AC-Delco parts. It's just the kind of maintenance every car needs to help it live a long and healthy life. For the AC-Delco retailer nearest you, call **1-800-AC-DELCO.**

AC-DELCO GENERAL MOTORS CORPORATION **IT'S LIKE BUYING TIME.**

BY TIMOTHY O. BAKKE

What's New HOME

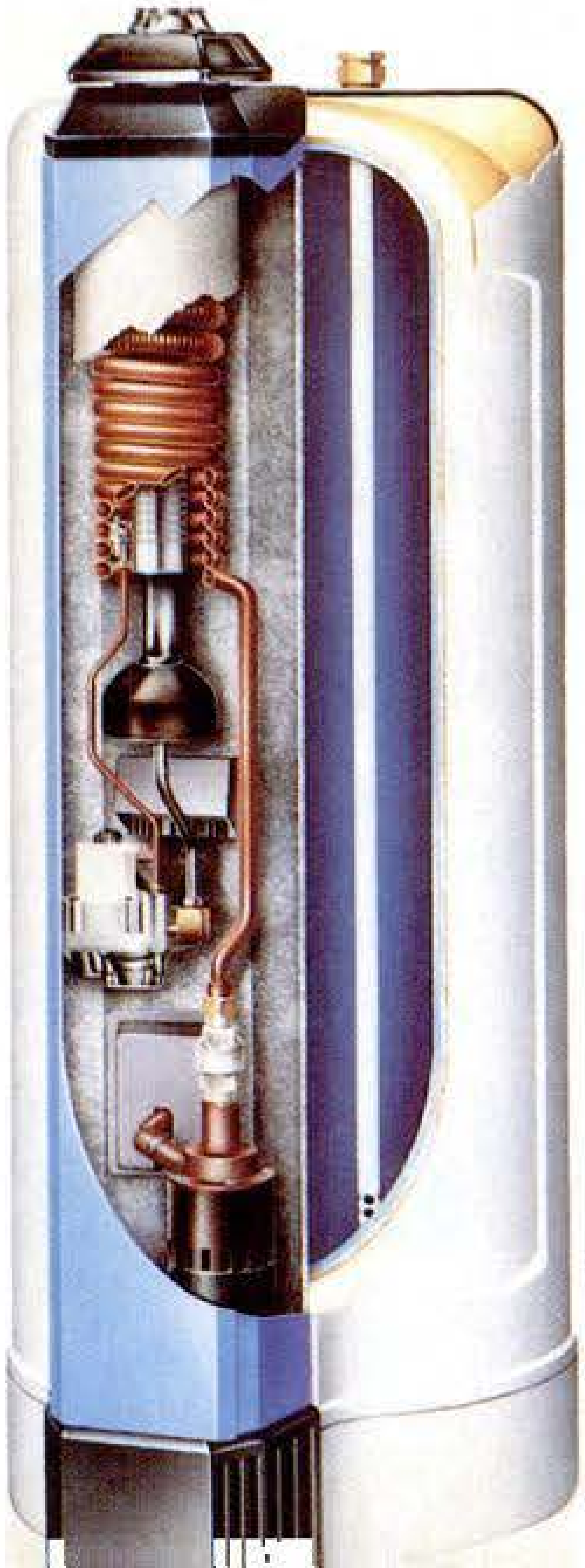


Covered outlets ▲

TayMac safety outlet covers provide protection with a difference: The enclosures snap shut even while receptacles are in use. The covers are weatherproof, but may be used indoors for child protection as well. They come in five styles and three sizes. TayMac Corp., 2440 W. 12th St., Tempe, Ariz. 85281.

Leak-proof water heater ▼

With its polybutylene seamless tank, the Marathon gas water heater is guaranteed not to leak for as long as you own your home, according to Water Heater Innovations (3107 Sibley Memorial Hwy., Eagan, Minn. 55121). Sizes: 40 to 50 gallons; prices: $700 to $750.



◀ Escape ladder

It weighs just nine pounds and folds up to a size you can fit under the bed, but the two-story All-Safe portable fire-escape ladder can hold a 600-pound load, says its maker. With wall standoffs and plastic sleeves between steps, the rope ladder is surprisingly rigid and easy to climb once deployed. Two-story size (12 feet by 6 inches): $90; three-story (20 feet by 6 inches): $130. Lumark Industries, Box 6262, Parsippany, N.J. 07054.

◀ Wipe off the weather

Mixed with water, Thompson's Wood and Deck Renewer cleans weathered wood faster than other powders, says Thompson/Formby Co. (825 Crossover Lane, Memphis, Tenn. 38117). The active ingredient, calcium hypochlorite, is a fast-acting chlorine bleach. Price for six ounces: $7; 30 ounces: $17.

Foam-safe water-based glue ▶

Latex-based Liquid Nails is the only panel and construction adhesive that does not degrade polystyrene (shown) or other insulating foams, claims Macco Adhesives. The water-based adhesive also gives off little odor and cleans up with soap and water. It can be used to bind drywall and prefinished panels, wood, metal, fiberglass, plaster, masonry, and ceramic tile, and is said to bridge gaps up to ⅜ inch. A 10½-ounce cartridge costs $3. Macco Adhesives, 925 Euclid Ave., Cleveland, Ohio 44115.

IS YOUR CAR DYING OF NATURAL CAUSES?

Now you can stop that deadly friction that tears away at your engine

USE Tufoil AND YOUR ENGINE WILL LAST... AND LAST...AND LAST!

"INVENTOR OF THE YEAR" AWARD AND INDUCTION INTO "N.J. INVENTORS HALL OF FAME" GOES TO INVENTOR OF TUFOIL

Stay in tune with your car!

You've seen the price of new cars...they go up every year! Cars get flimsier...prices get higher...it never seems to end. There are lots of reasons to keep that nice car of yours on the road as long as possible.

Car sales are down and Tufoil sales are up. People are smart...they're taking the economical way out and what could be easier than Tufoil. Just add 8 oz. to the crankcase the first time and 4 oz. each time after that. You don't have to shake the container or add an engine flush. Just pour it in and drive away!

Your throttle will get silky smooth...acceleration will improve. One customer said his car "takes off like a scared rabbit!"

Tufoil works wonders for all known engine oils. It's actually slipperier than Teflon (according to a famous U.S. Government laboratory).

You'll get astonishingly fast starts on cold mornings with both diesels and gas engines. The Canadian government tested Tufoil at it's cold regions lab. They showed faster cranking and significant fuel savings with Tufoil.

What about additives that claim to be a one-time treatment that will last the life of an engine? Well, I've been following the scientific literature on lubrication for a very long time. As far as I know, there isn't a shred of scientific evidence for such a claim. So don't believe it!

TREAT YOUR CAR TO ONE 8 OZ. BOTTLE OF TUFOIL FOR ONE OIL CHANGE

You'll notice quieter, smoother operation, quicker starting, snappy acceleration! If you don't, just send us proof of purchase and we'll refund the price of an 8 ounce container.

Send for Tufoil today and prove to yourself the amazing increase in your car's performance. Fill in the coupon today or call TOLL-FREE any time, 24 hours a day.

1-800-922-0075. ☎

Engines last longer with Tufoil. Our 1976 476 T-Bird is now at 190,000 miles and purring.

A bunch of customers' cars have now passed 250,000 miles.

Several months ago, a nice man I'd never seen before walked into my office, big smile on his face, sat down and said, "Would you believe 340,000 miles on a Tufoil engine?" He went on to rave about how well his engine has been running all these years. I couldn't get a word in edgewise.

Recently, a truck driver called in with over 1,000,000 miles on a diesel using Tufoil - WOW!

A customer from Vermont added 10% Tufoil to his sticky mechanical transmission, called in and said he couldn't believe it..."Shifting is like slicing butter now!" he said.

SAAB owners are writing letters praising Tufoil in their "NINES" magazine. They report spectacular improvements in their engines and transmissions!

Don't forget! Tufoil is the result of over 15 years of research and development. The U.S. government has awarded us 6 patents so far...so have Germany, England, France and Canada.

No other lubricant even comes close.

FREE . . . Products based on TUFOIL technology. Check one with each order of 2 bottles or a quart. Check 2 for each gallon order. Values range from $3.98 to $9.95.

- ☐ TUFOIL Gun-Coat — Super rust inhibited, smooth action
- ☐ TUFOIL Compu-Lube — Low viscosity for computer mechanisms
- ☐ TUFOIL Lightning Grease — Easily sheared grease for instruments
- ☐ TUFOIL Lubit-8 — General purpose, household use lubricant

FREE brochures . . .

- ☐ 30 Questions/Answers about TUFOIL

When POPULAR MECHANICS tested TUFOIL, it reported "TUFOIL is absolutely spectacular!"

FLUON® is reg. T.M. of ICI Americas Inc.
TEFLON® is reg. T.M. of DuPont*
TUFOIL® is reg. T.M. of Fluoramics
U.S. Patent No. 4.284.518
U.S. Patent No. 4.224.173
U.S. Patent No. 3.933.656
Other U.S. Patents issued and pending.

YES rush my TUFOIL order:

- ☐ ONE 8 oz. bottle . . . treat one car for $14.25 (plus $3.50 shipping and handling). See money back guarantee.
- ☐ TWO 8 oz. bottles . . . treat two cars for $25.00 (plus $4.00 shipping and handling) **SAVE $6.00**
- ☐ ONE Quart bottle . . . treat 4 cars for $34.95 (plus $4.00 shipping and handling)
- ☐ ONE GALLON . . . treat 16 cars for $125.00 (plus $6.00 shipping and handling.)

We ship within days!

MONEY BACK GUARANTEE ON 8-OZ.

Fluoramics, Inc. PS890
18 Industrial Avenue
Mahwah, NJ 07430

My check or money order for $ _____ is enclosed.

Charge my credit card:

☐ Am. Express ☐ Master Card ☐ Visa

Card No. ____________

Exp. Date ____________

Phone No. ____________

Name ____________

Address ____________

City ____________

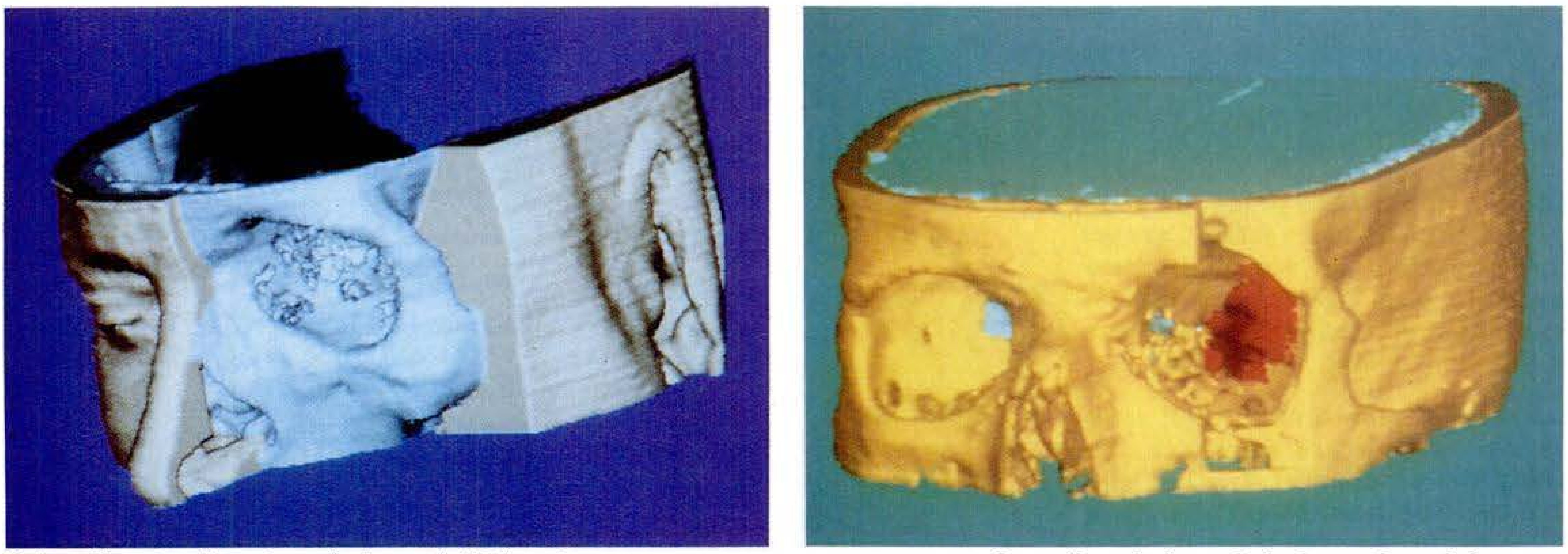
State ________ Zip ________

(N.J. residents please add 6% sales tax).

Canadian Distributor: 1-800-363-7753

Science Newsfront

By ARTHUR FISHER



A three-dimensional imaging technology called Volume Investigation can construct pictures ranging from cells to the human body that can be peeled away to reveal layers that are ordinarily hidden. The system was developed at The Toronto Hospital in Canada.

The skull beneath the skin

The pictures above convey only a fraction of the possibilities of a new form of medical imaging. Called 3D Volume Investigation (VI) by its practitioners at The Toronto Hospital in Canada, it is a revolutionary system that allows an investigator not only to see objects three-dimensionally, but to peel back layers one at a time to reveal features otherwise concealed.

"Volume Investigation will change the way we all do science," claims Dr. Kristen Harris of Harvard Medical School, who has used the technique to study the cellular basis of learning and memory. "It's as if we have been blind...and suddenly we have been given sight."

The heart of the VI system is a mini-supercomputer, the ICAR 80.8, developed in part by ISG Technologies of Mississauga, Canada. This work station takes images of a given subject created by confocal laser microscopes, electron microscopes, CT (computerized tomography) scans, and magnetic resonance scans. It assembles these diverse images and reconstructs them on a monitor as 3-D images that can be rotated at will by the viewer and examined from any perspective.

Unlike other 3-D systems, however, 3D Volume Investigation allows the researcher to slice into the image, peel back individual layers, and measure volumes within (thus the name, Volume Investigation). This would enable a physician, for example, to calculate accurately the extent and mass of a hidden malignant tumor.

"This technology assimilates twenty to forty CT slices into one picture," says neurosurgeon Dr. Chris Wallace, who takes along a computer terminal with VI images into surgery. "It means that instead of imagining what it's like to add the CTs together, the computer visualizes it for me. And in the cases where I've used VI images so far, they have been dead on."

The new technique also offers unusual flexibility in biological studies at the cellular level. Two-dimensional microscopic images can be stacked as a series of cell slices stained with antibodies. Then the stack can be reconstructed to show the 3-D shape of the cell, as well as its contents.

Says Dr. Robert Inman, an immunologist at The Toronto Hospital, "The technology has already started to change the way we understand the clinical pathology of cells."

Fat facts

Someone once drew a cartoon, now immortal, that summarized what many physicians think about their overweight patients. It shows a plump woman saying to her doctor "But I eat like a bird." And at his desk, the weary doctor sits with a cartoon balloon floating above his head with his real but unspoken thought pictured within: a vulture rending its prey.

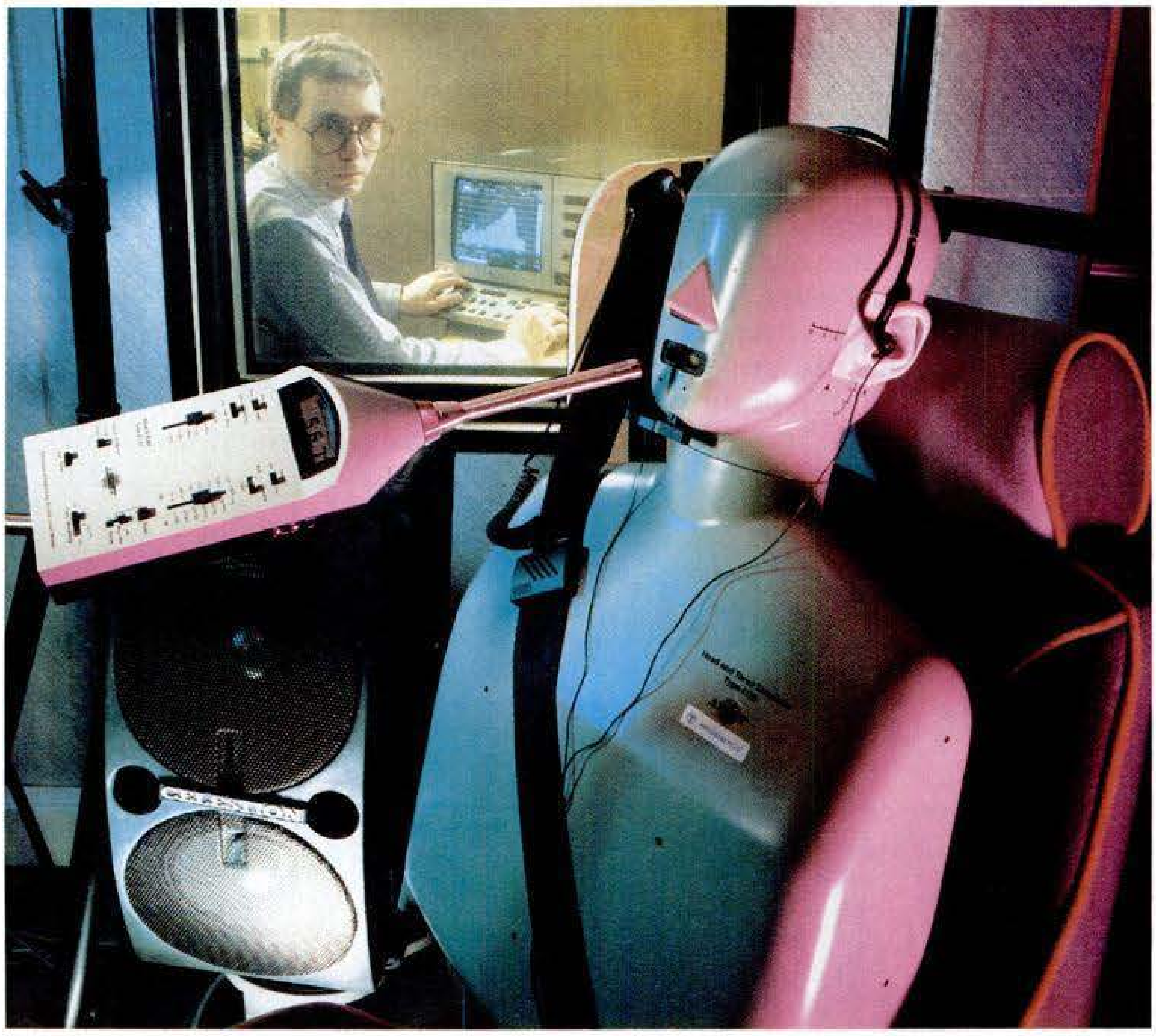
Now there is new evidence to support a belief that has been growing inside the medical establishment for years—that some people can eat as much as they want without gaining weight while others, ingesting the same amount of food and at the same level of caloric expenditure, get fat. The difference, two new studies show, is genetic.

One study, by Dr. Claude Bouchard at Laval University in Quebec, found, for the first time, that some individuals inherit the ability to burn excess calories by inefficiently converting them to muscle. But others inherit a mechanism that efficiently converts almost all their extra calories directly into fat. The evidence came from stuffing pairs of identical twins with a total of 84,000 surplus calories over a 120-day period.

Both twins in each pair gained the same amount of weight. But the variation in what these twin sets gained was striking: The pair with the "best" genes gained only $9\frac{1}{2}$ pounds; the pair with the "worst," an ungainly 29 pounds.

The second study was performed by Dr. Albert J. Stunkard and colleagues at the University of Pennsylvania. They compared the body-mass index (weight adjusted for height) of the members of twin sets that had been reared apart against those that had been reared together. But they examined both identical twins and fraternal twins (who do not share identical genetic patterns).

The results showed a clear genetic influence. Even if identical twins had been reared apart, so that they were subject to different cultural, educational, and economic circumstances, they had nearly identical body-mass



A dummy developed by British Telecom that simulates a head and torso is helping in the design of a new mobile cellular phone system that is planned for all of Western Europe.

indices. So did the identical twins who had grown up together. But the fraternal twins exhibited much greater differences, even when they had grown up together.

Both studies were reported in *The New England Journal of Medicine*. In an accompanying editorial, Dr. Ethan Sims, professor emeritus at the University of Vermont in Burlington, wrote that we now have "the most definitive answer to date to the question of whether...environment or genetic heritage is predominant" in determining fatness in Western society.

Telephone dummy

You might say the figure in the photo at the top of the page is the ears and mouth of a new mobile telephone communications system. Equipped with these (artificial) organs, this dummy is called HATS, for head and torso simulator. It is being used by British Telecom's research laboratories in Suffolk, England, in a project that will affect mobile-phone users all over Europe, one that is being joined by communications organizations in Germany, France, Italy, Norway, Sweden, Finland, and the Netherlands. Each of these countries now has its own non-compatible cellular radiotelephone system.

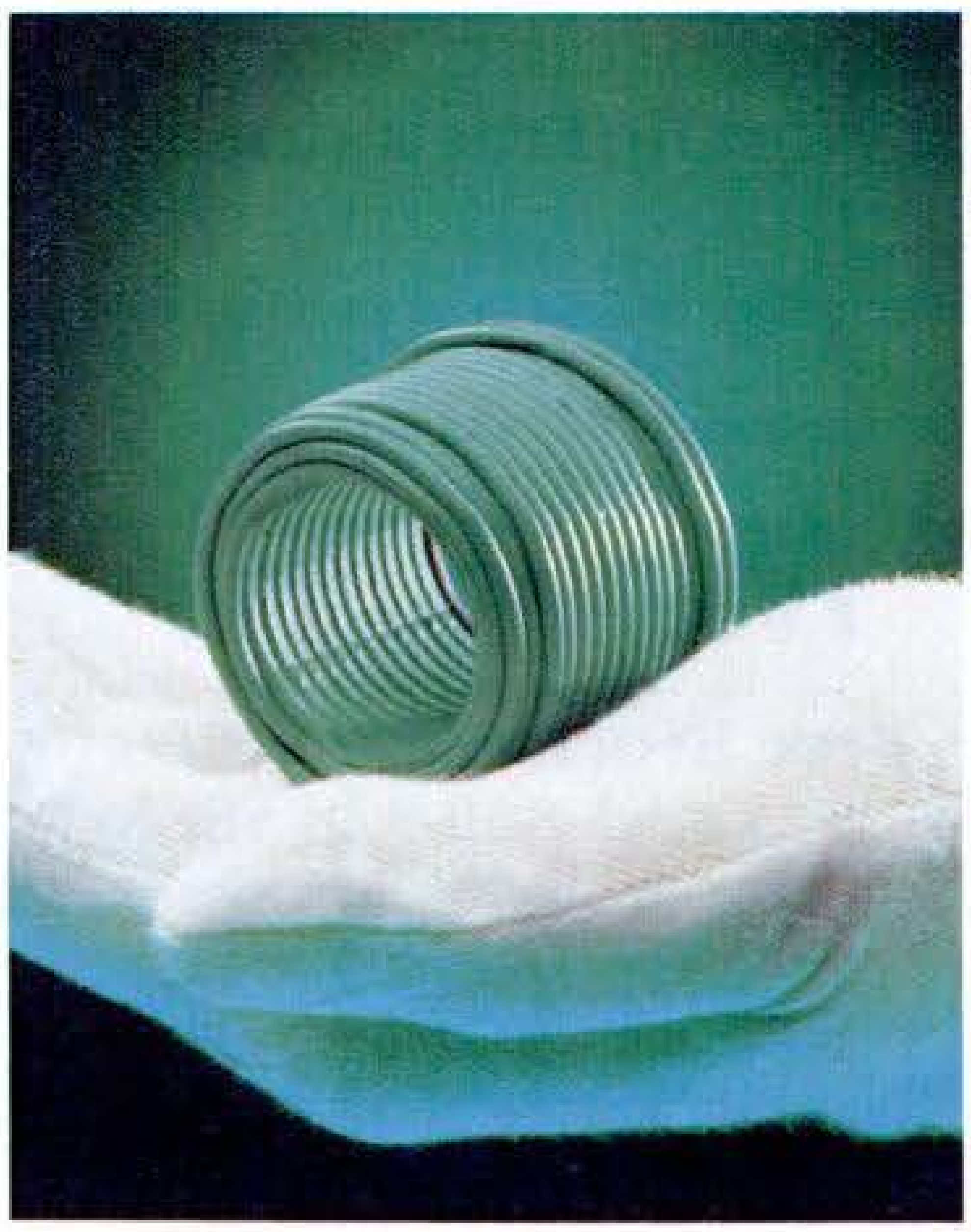
The HATS dummy is placed in a "silence cabinet" with a microphone attached to its seat belt. The researchers play an artificial voice through the dummy's mouth to establish the sensitivity of the mike; a meter pointing at the head measures the sound-pressure level of interfering noises piped into the cabinet that represent nuisances, such as trains.

The British Telecom researchers plan to use the data thus gathered to make a system that recognizes the difference between a phone user's voice and other distracting sounds. The aim is to make use of the pauses in conversation, with a detector switching off the transmitter during them, freeing the radio frequency for other calls. As soon as one speaker resumed talking, the detector would instantly switch a line back for use.

That development would boost the capacity of a proposed pan-European digital cellular mobile radio system, due to come on line in 1991.

Green is for go

The bright-green Slinky-like object in the photo at right is a 30-foot coil of superconducting wire. The news is that it is made from one of the new breed of high-temperature superconductors that can operate at liquid-nitrogen rather than liquid-helium temperatures. These materials are ceramics and brittle. Fashioning them into large coils that can be used in magnets, motors, and other large-scale applications is one of the chief obstacles to their widespread use. And one of the most significant problems to be overcome has been how to insulate such a coil without vitiating its superconducting properties.



This coil is insulated with a version of a high-temperature superconductor.

The coil shown, made at Argonne National Laboratory, is one successful approach. The Argonne solution was to make the insulation for the coil from the same material as the superconductor, but slightly modified.

The best known high-temperature material, explains Argonne materials scientist Roger Poeppel, is the compound known as "one-two-three" because it is made of yttrium, barium, and copper oxide in the ratio of 1:2:3. Changing the ratio to 2:1:1 converts the compound into an insulator that has a natural bright-green color pleasingly like that of conventional plastic wire insulation.

The Argonne coils have a current-carrying capacity of 100 amperes per square centimeter. That is about one-third the capacity of copper coils in conventional motors. But Poeppel says it is easily high enough to begin experimental tests. The first motor using the coils has been built by the Reliance Electric Co. of Cleveland in an experimental project that is being funded by the Electric Power Research Institute.

Open-eyed Hubble

Astronomers at the Goddard Space Flight Center in Greenbelt, Md., are jubilant over the quality of the first images returned by the Hubble Space

Telescope after its much-delayed but finally successful shuttle launch on April 25 ["SNF," April].

The pictures were made with Hubble's wide-field camera, one of five major instruments aboard. The camera made one-second and 30-second exposures of a cluster of stars named NGC 3532, a southern sky constellation 1,260 light-years from Earth.

Jean Olivier, deputy project manager, explained that the pictures were made as part of a "break-in" procedure that will take some eight months before all of Hubble's instruments are fully operational. "This is an engineering test," he said, "not a test of our full capability."

Nevertheless, scientists were surprised and pleased at the sharpness of these first images, especially so because the lengthy and finicky shakedown—consisting of testing and adjustment—is in such an early stage.

"The images were at least twice, if not three times, better than expected," exclaimed James Westphal, project scientist for the wide-field camera.

To gauge the quality of Hubble's images, Goddard scientists matched them against pictures of the same star cluster taken with the 100-inch telescope at the Los Campaños Observatory in Chile. "We were expecting to see something pretty much like the ground-based picture," Westphal said. "But we saw something obviously much sharper."

The sun in X-rays

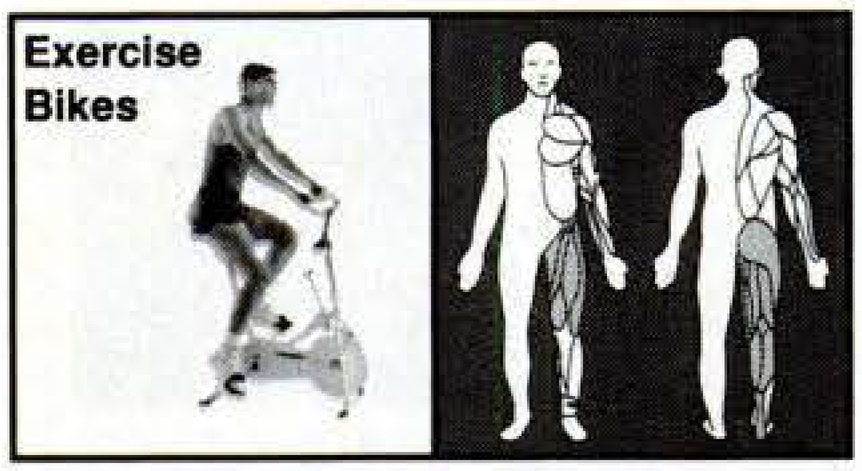
Details never before seen of the sun's turbulent outer atmosphere and violent energy releases have been recorded in the sharpest solar X-ray images ever made, one of which is shown on the next page. The pictures were taken with a specially designed X-ray telescope aboard a NASA sounding rocket lofted 150 miles above the White Sands Missile Range in New Mexico. The project is a collaboration between scientists at the Smithsonian Astrophysical Observatory in Cambridge, Mass., and IBM in Yorktown Heights, N.Y.

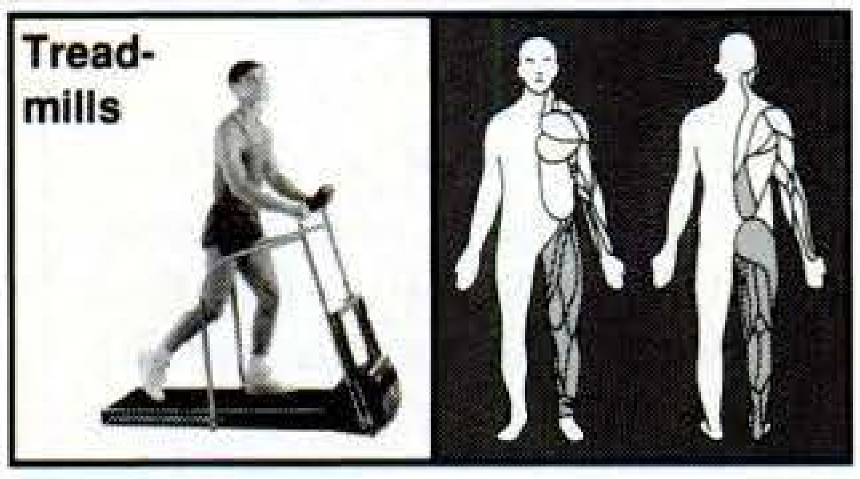
Electromagnetic energy from the sun pours forth in a whole spectrum of wavelengths. The hotter the part of the sun emitting this energy, the shorter the wavelength. Visible light is from the surface, or photosphere, where the temperature is in the thousands of degrees. But the solar corona—the tenuous outer atmosphere of the sun beginning 2,000 miles from its surface—can reach millions of degrees, and the "light" generated there is in the form of X-rays, which have very short wavelengths.

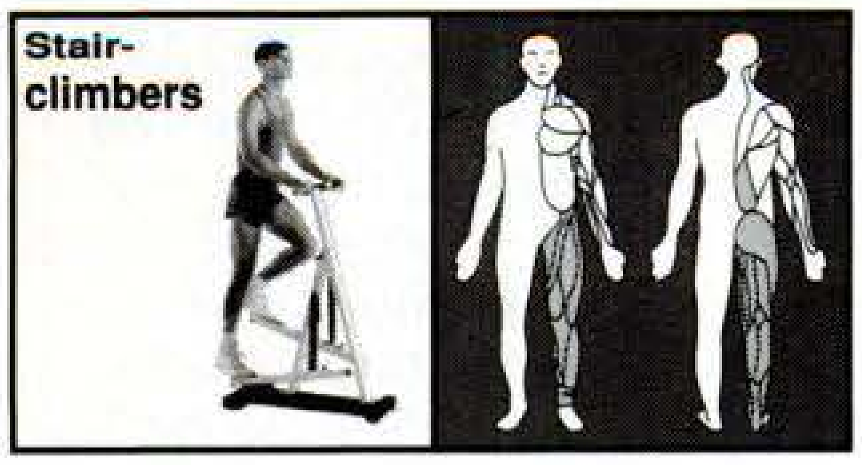
The 38 pictures parachuted to Earth from the NASA rocket have enabled solar astronomers to record activity in the corona with a resolution more than twice that ever before achieved; they can now study solar features as small as 0.04 percent of the sun's diameter, or 340 miles. Seen in pictures like the one shown are active, hot regions in which magnetic fields emerge from the solar surface, with much new structural detail. The shapes and sizes of the looplike features reflect the complexity of the underlying photosphere, and the enhanced resolution now available may provide solar physicists with a better understanding of the puzzle of why the corona is so hot.

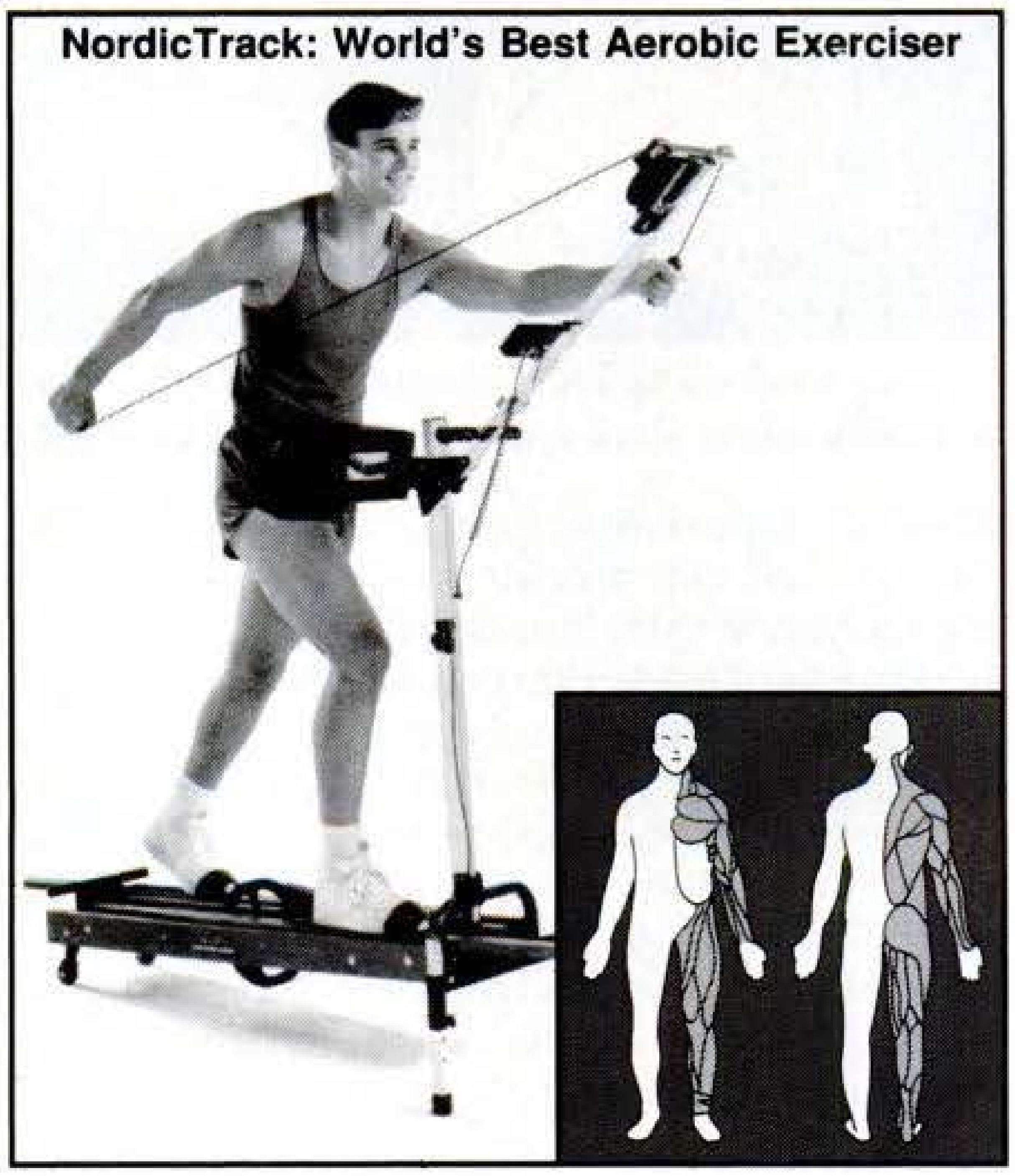
The images also provide new details of perhaps the most dramatic of the sun's phenomena—solar flares. One such flare, of the variety known

Only NordicTrack gives you a total-body workout.









Treadmills, exercise bikes and stairclimbers don't give you half the workout NordicTrack does.

If you're thinking about buying an in-home aerobic exerciser, consider this.

For the most part, most exercisers ignore the muscle groups in your back, your chest, your shoulders and your arms.

Meanwhile, NordicTrack exercises all the major muscle groups in both your upper and lower body.

NordicTrack's lower-body exerciser works your hip flexors, gluteus muscles, thighs, hamstrings, knee extensors and calves. Its upper-body exerciser works the extensor muscles of your back, your trunk, rotators, biceps, triceps, chest and upper back.

By doing this NordicTrack quickly and comfortably elevates your heart rate to the fitness-building level.

And of course, it burns more calories than any other type of aerobic exercise machine.

Why settle for less than a total-body workout?

Get on track with NordicTrack.

NordicTrack
A CML Company

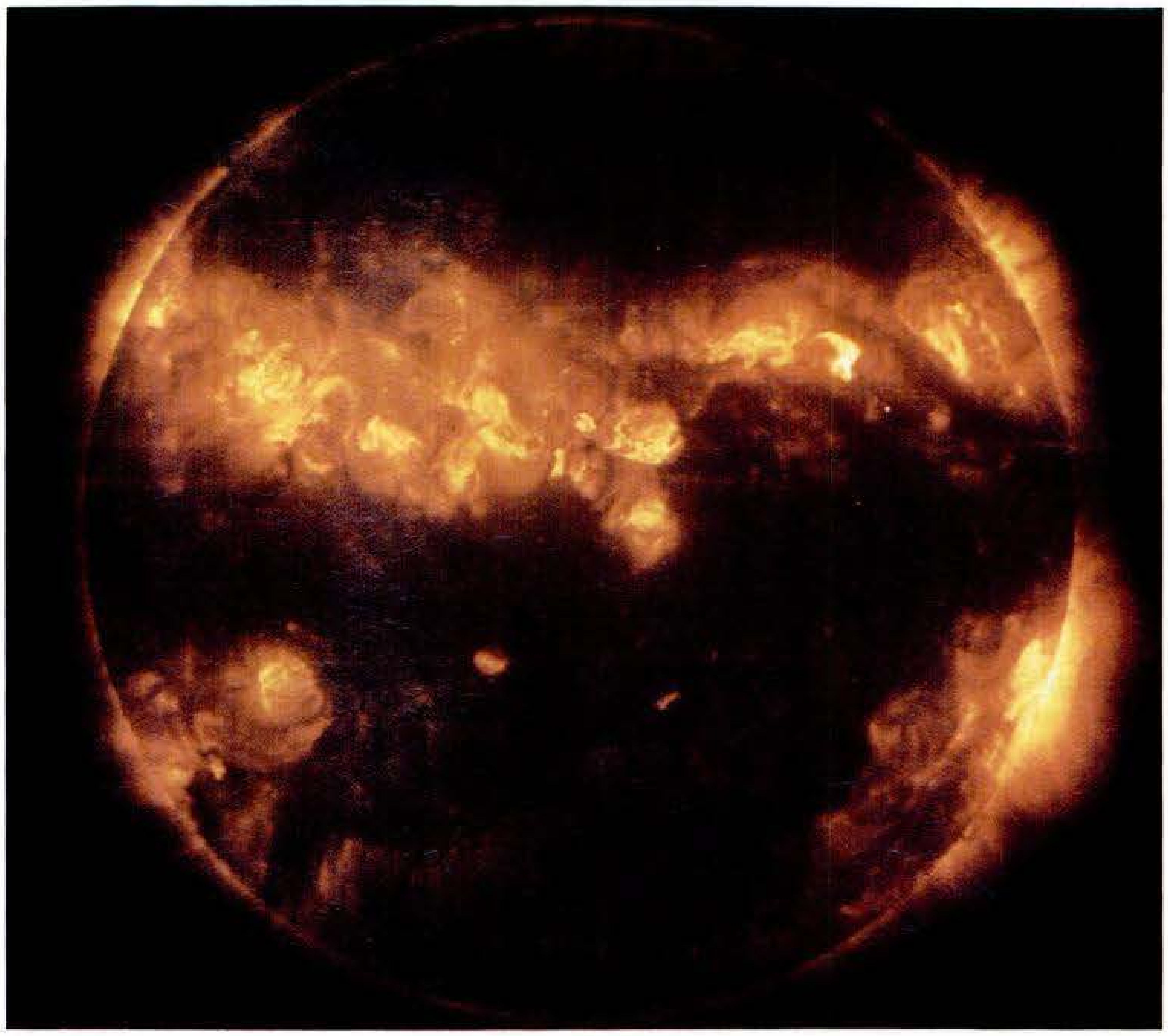
Free Brochure & Video
Call Toll Free 1-800-328-5888
In Canada 1-800-433-9582
☐ Please send me a free brochure.
☐ Also a free video tape ☐ VHS ☐ BETA
Name ______
Street ______
City ______ State ______ Zip ______
Phone ( ) ______
141C Jonathan Blvd. N., Chaska, MN 55318
280HO

as two-ribbon, probably reached temperatures of 10 million degrees C.

The project's principal investigator, Leon Golub of the Smithsonian, says: "Coronal activity affects the Earth and the Earth's upper atmosphere in a number of ways, some of which might not be known. The new telescope is a major improvement that allows us to see that activity directly, offering the hope that we might understand its causes, thereby possibly allowing us to predict future activity and its influence on the Earth."

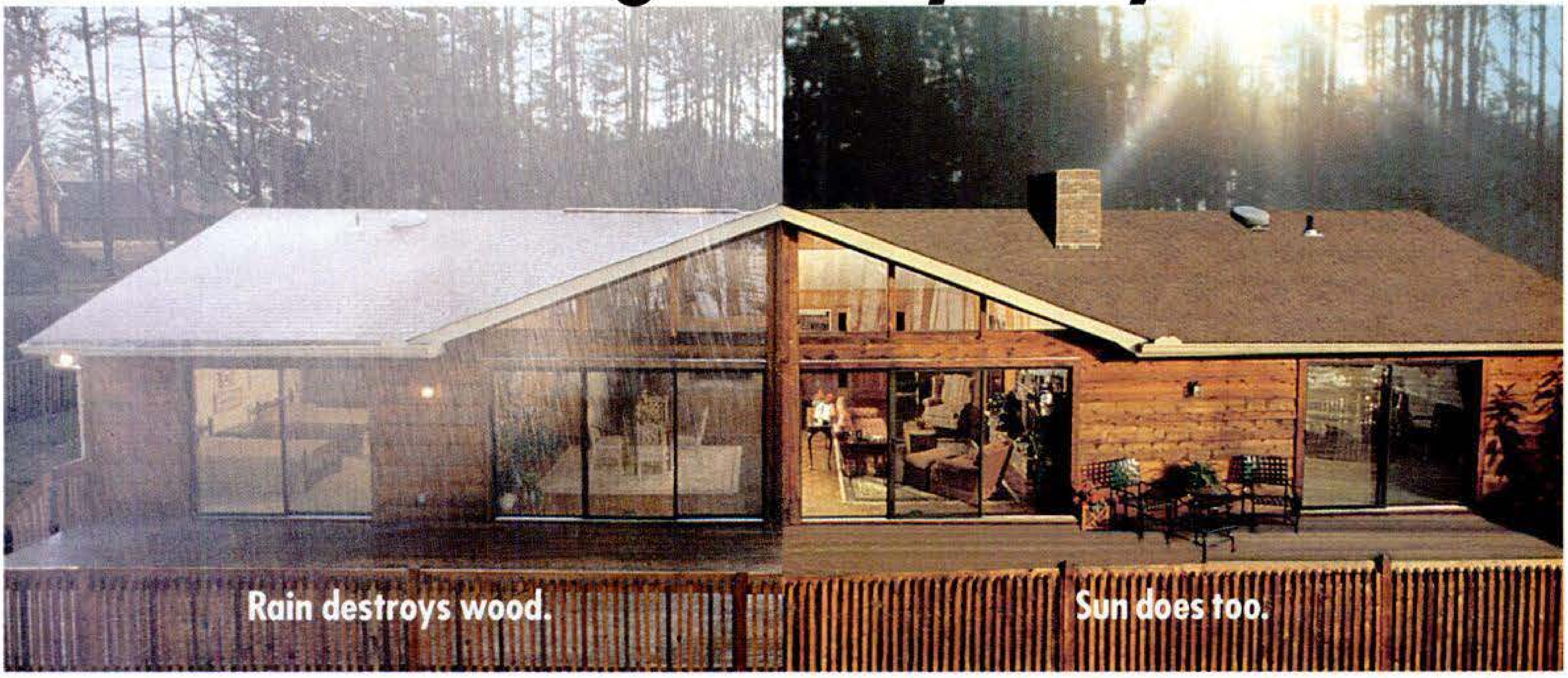
The heart of the X-ray telescope is a mirror consisting of 140 layers —each a few atoms thick—of carbon and cobalt. (Conventional lenses and mirrors can't focus X-rays.) The thickness of each layer was chosen to record only features of one specific temperature—characteristic of certain X-ray emissions in the corona.

That and the use of special filters ensured that the images would be sharp and not blurred by X-rays emitted at other temperatures or by visible, ultraviolet, and infrared light —to all of which the fine-grain, high-resolution film used in the experiment is sensitive.



This photo is one of a series made with a newly developed X-ray telescope in a Smithsonian Observatory/IBM joint venture. The photos are the sharpest ever made of the sun in X-rays.

There's never a good day for your wood.

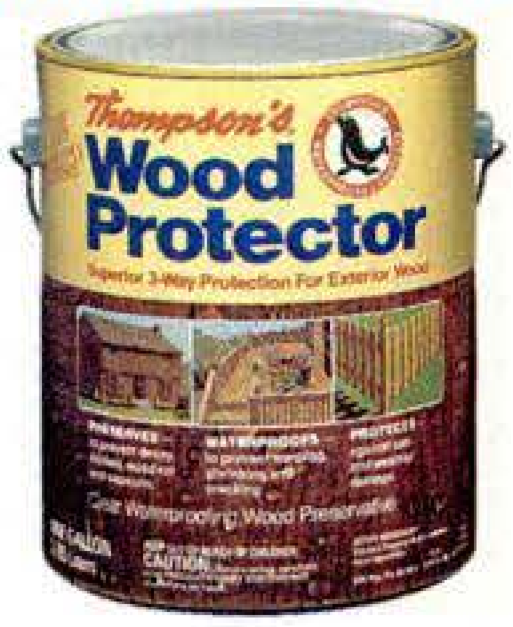


Thompson's protects full-time against water, sun and mildew.

Your house is constantly being attacked by sun, wind, rain, mold and rot. That's why your wood needs the full-time protection of Thompson's® Wood Protector.

Thompson's unique formula contains powerful waterproofers to protect against splitting, cracking and warping; mildewcides to prevent mold, mildew and rot; and sunscreens to help prevent fading and greying. So use Thompson's Wood Protector. You'll see how just one coat can give your home full-time protection for a longer life expectancy than you ever expected.

© 1990 Thompson & Formby, Inc.



Electronics Newsfront

By **DAWN STOVER** *with Mariette DiChristina, William J. Hawkins, Dennis Normile, David Scott, Marcelle M. Soviero, and Judith Anne Yeaple*

Room with a view

Hospital patients with scenic views seem to recover faster, complain less, and require less pain medication. That's why federal law requires that all inpatient hospital rooms built or remodeled after 1977 include a window.

Recent renovations at Stanford University Medical Center's cardiac intensive-care unit left three rooms without windows. "No windows, no beds," says nature photographer Joey Fischer, who designed computer-controlled artificial windows for the rooms (see photo). The electronic windows look so much like the real thing that officials have temporarily exempted them from the law.

Fischer describes his windows as "giant color slides." Behind each blowup, a computer-driven light box uses several hundred light bulbs to produce 650 subtle light changes a day—from sunrise to sunset. "You just set the digital timer to the real time," explains Fischer, "and the window automatically simulates the light cycle." Future versions may include motion and sound—twinkling stars or waves lapping at the shore, for example.

Fischer customizes each window —which might account for the $20,000 price tag. "For the Stanford window I shot a scene of the Palo Alto hills," he says. "If I were designing a window for a New York hospital, I'd shoot a scene from that area."

Hospital administrators aren't Fischer's only customers. The U.S. Navy has ordered a few windows for its nuclear submarines. And a group of Ohio residents living in basement apartments are also eager for a bit of simulated sunshine.

Art Research Institute Ltd., 4235 Pickney Dr., Woodland Hills, Calif. 91364.

Stanford University Medical Center's electronic window uses a computer-driven light box to simulate natural scenes and lighting, which studies show help a patient recover faster.

Banking by phone

At-home banking isn't new, but it's inaccessible to people who don't own personal computers—many of whom are uncomfortable with high-tech gadgets. Hoping to expand the home-banking field without scaring off those "technophobes," Citicorp and its subsidiary, Citibank, turned to the one device everyone uses—the telephone.

Citicorp is betting its customers will gladly bypass long lines and inconvenient banking hours for an Enhanced Telephone—a phone-computer hybrid that lets customers conduct banking transactions 24 hours a day.

About the size of a shoe box, the Enhanced Telephone looks reassuringly like a phone, except for a small liquid-crystal display mounted between the handset and numeric key pad. A keyboard with the alphabet, hidden underneath the phone, slips out when needed.

Despite the device's uncomplicated look, it contains a small computer. The screen lists four options: An option to dial calls, an emergency-numbers list, a list for frequently dialed numbers, and a banking functions list. Those functions include updates on account balances, money transfers between accounts, lists of cleared checks, and a bill-paying system. You can program it either to pay bills on a regular basis —say, the cleaner's bill every Tuesday morning—or to pay specific bills. What *can't* you do? Get cash.

Four hundred Enhanced Telephones have already been installed in the New York area for a one-year test program. The company projects that future subscribers will be able to lease the machines for $10 per month, plus a $50 installation fee.

Mobile phone

Incoming calls to car phones are easy to miss. And devices that honk the horn to alert you to a call can even be a problem—you usually dash out of a store or restaurant and reach the car just as the caller hangs up.

Now Advanced Cellular Technology (ACT) in Santa Clara, Calif., has designed a car phone extender that lets you answer calls immediately. Called Celltalker, the $240 device transmits incoming calls from the car phone to a portable handset.

When someone dials your number, a four-by-six-inch base unit attached to the mobile phone's transceiver relays the call to the remote handset. To answer, just press the "talk" button. (The system does not let you dial outgoing calls.)

Compatible with most cellular phones, the multiple-channel device lets you answer an incoming call from as far away as 1,000 feet. (An "In Range" light warns you when you stray too far from your car.)

Henri Van Houten, ACT's vice president of sales, claims you can attach the base unit in 10 minutes.

Special delivery

You're flying out of Boston at 7:00 a.m., and you'd like to leave a message for the person who'll be meeting your plane in San Francisco later that day. But with the time difference, it's much too early to call your friend. Now there's a way to record a one-minute message and schedule it for delivery up to a week later: Dial AT&T's VoiceMark Messaging Service at 1-800-562-6275, and follow the instructions.

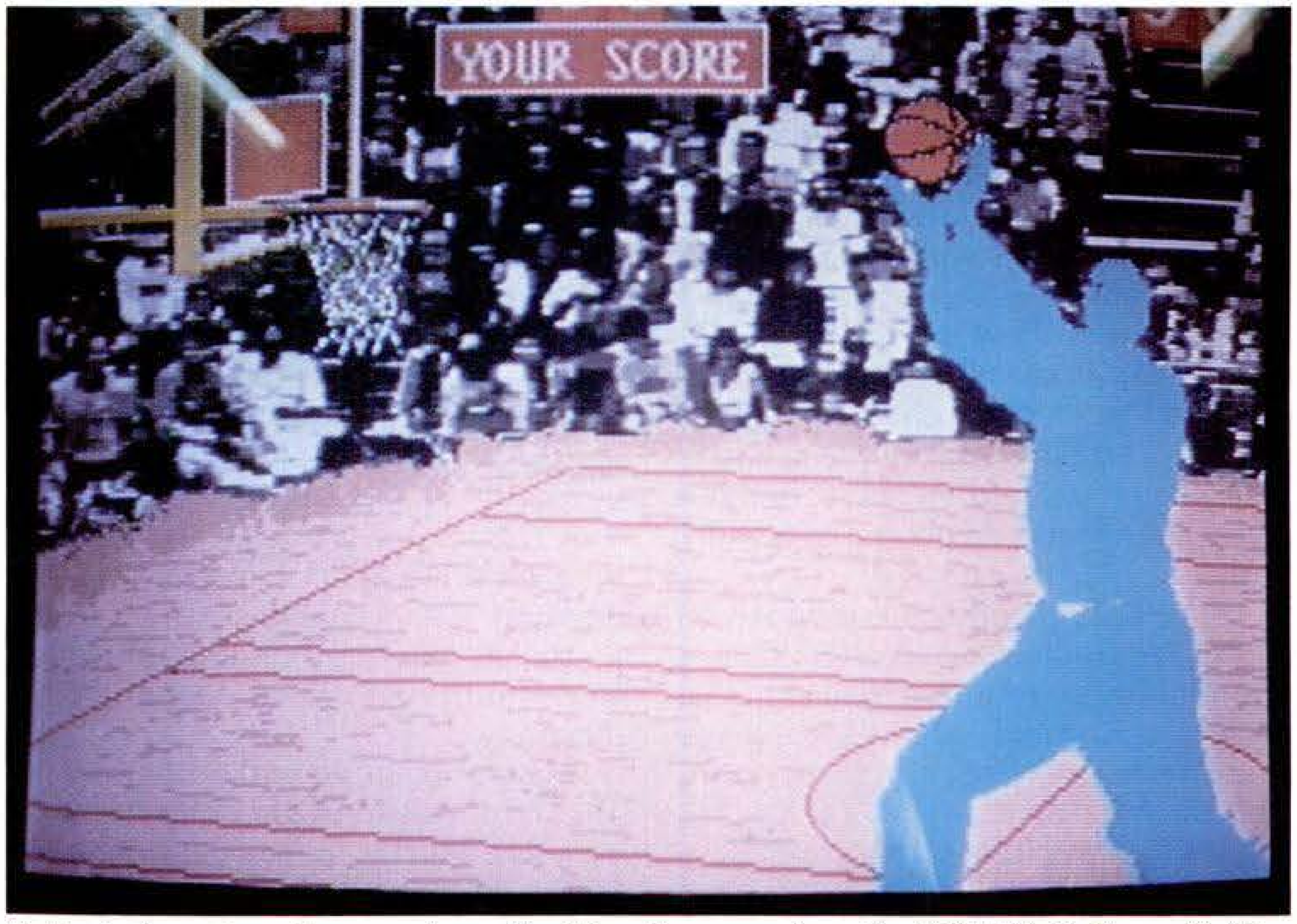
The VoiceMark service costs $1.75 for automated delivery within the United States; person-to-person delivery is $2.50. The recipient can record a one-minute reply at no extra charge.

Sky spies?

Many trucking companies and others are using satellites to send messages to drivers in moving vehicles ["Hello Satellite, Get Me Central," April]. Now Qualcomm Inc. is adding positioning by satellite as well. It promises greater accuracy and reliability for current systems while perhaps paving the way for miniaturization of such communication systems for hand-held or automotive use.

Qualcomm dubbed the technique QASPR, for Qualcomm Automatic Satellite Position Reporting. It can track vehicles to within 1,000 feet 24 hours a day—a plus when you're monitoring sensitive loads such as hazardous material, explosives, or ammunition, says the company.

Until now, mobile satellite-communications systems used Loran C to determine position. Loran, which stands for LOng-RAnge Navigation, was developed by the U.S. Coast Guard and is used by marine and land vehicles and in private aviation. It employs radio waves transmitted by a pair of ground stations to calculate position. However, Loran's accuracy varies from $\frac{1}{10}$ mile to a mile, depending on location. Some areas—notably in the Southwest—are Loran "holes." (However, the planned construction of two new Loran chains in the center of the country may eliminate this problem.)



You're in the action when you play a Mandala video game from the Vivid Effects Group. A video camera captures your movements, which are added to the game's graphics.

How does QASPR work? "We process the two-way communications signal from one satellite and monitor a beacon signal from a second satellite," says Bill Ames, a senior engineer at Qualcomm. "We know that the signals travel at the speed of light, and we know how fast that is," he explains. "By measuring the time it takes for the signals to travel to and from the satellites, we can calculate location. We measure down to the tens of nanoseconds [a nanosecond is a billionth of a second] range."

Qualcomm European customers already have QASPR because Europe doesn't have the Loran network, says the company.

Live action

A game developed by New York-based Motiontronics for Science Inc. lets two players fight a full-fledged boxing match without risking black eyes or bloody noses.

Radio transmitters attached to the players' hands or boxing gloves send signals to sensors placed at punch points—located on the headgear, chest straps, and belt. Players stand a few feet apart and shadowbox, scoring points when the sensors detect punches.

An even more sophisticated system, developed by the Vivid Effects Group in Toronto, lets you step into the middle of video games (see photo). Called Mandala, the system consists of a video camera, a computer, and a monitor. The player faces the monitor, and the camera picks up his movements, then uses special software to display his image in the midst of the game's on-screen graphics.

"Areas all over the screen let you interact with animation and sound effects," says Sue Wyshynski, vice president of Vivid Effects. One game allows you to creep cautiously through caverns, opening dungeon doors with your animated key. Another, at the Hockey Hall of Fame in Canada, lets you play goalie. When a puck is shot, you move your arms or legs to make the save.

Vivid Effects is working on an inexpensive home version that would connect to a television set. Also under development are telecommunications applications. "It's the phone of the future," claims Wyshynski. Mandala is currently set up at Bell Canada where, using a video switch, callers in New York and Toronto can step into the same video world. "We've had people walking through gardens together and picking flowers, while they're on the phone," says Wyshynski.

Electronic tollgate

Drivers passing through a tollgate on the E6 highway in central Norway don't have to wait in line or hunt for coins. The electronic tollgate recognizes cars bearing special ID tags, then automatically bills the registered owners or debits their prepaid accounts. Motorists without the tags, which can be obtained from banks and post offices, must stop at a cash-payment booth.

The Q-Free system has a radarlike unit at each tollbooth that continuously scans the approach lane. The scanning signal is bounced back as a unique code by the ID tag, a passive transponder in a small plastic case stuck to the vehicle's windshield behind the rear-view mirror.

Booth units record each reflected signal, and pass the vehicle's ID to a financial accounts computer. If a tagless driver tries to sneak through a gate, the computer activates a video camera.

Other Q-Free gates are planned for highways around Oslo and Trondheim. Trondheim-based Micro Design makes Q-Free and vehicle identification systems for parking lots and train yards.

New hues for facsimiles

Sharp has announced the first full-color desktop-size fax. (Starsignal Inc. of Campbell, Calif., introduced a $20,000 color fax last year, but it doesn't fit on a desk top.)

In Sharp's machine, documents aren't fed past a line scanner. Instead, originals are placed one by one atop a glass screen like the ones used in copiers. A sensor, roughly 8½ by 11 inches, scans the entire area at once. To speed transmission, the digitized data are compressed at the originating machine and expanded at the receiving end. Sending one page takes three minutes.

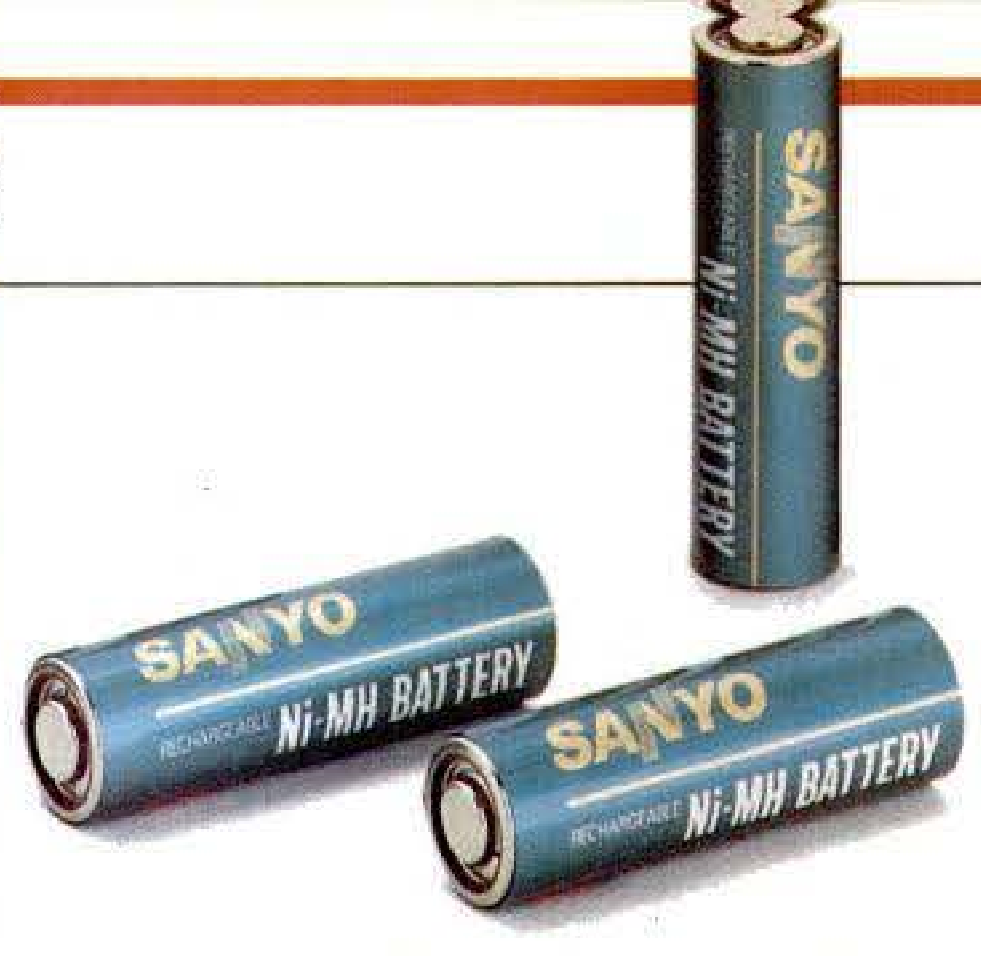
The machine uses a sublimating printer in which a dye-laden ribbon the width of a sheet of paper is stretched across a thermal head. A thermal process prints the color image on the paper.

The color facsimile uses plain white paper, but a special finish is recommended for "superior quality" reproductions. Color adjustments are automatic. A separate adapter is needed to communicate with conventional facsimiles.

Sharp's machine will go on sale in Japan this autumn for approximately $23,000. North American sales will begin later. Sharp expects to make the machine smaller, and competition will likely make it cheaper. Companies such as Canon and Ricoh are rumored to have color facsimiles under development.

Sharp's facsimile machine sends and receives images in color. The $23,000 device is designed to fit on a desk top.

Better battery



Sanyo's nickel-metal hydride battery has 1.8 times the energy density of nickel-cadmium cells.

A rechargeable battery developed by Sanyo Electric in Japan has an energy density 1.8 times that of conventional nickel-cadmium batteries. Sanyo's cell combines a nickel electrode with a metal hydride electrode (see photo).

Charging the nickel-metal hydride storage battery takes about 1½ hours. All of the energy can be discharged in as little as 20 minutes, providing enough energy to operate a cellular phone, lap-top computer, or video camcorder.

Sanyo claims that its new battery, which can be recycled, is environmentally superior to nickel-cadmium cells.

Sanyo will release an American version of the battery this fall. It will cost about twice as much as a nickel-cadmium battery.

Speech synthesizer

Bellcore researchers claim to have designed a speech synthesis system that's much easier to understand than existing systems. In lab tests that compared the experimental system, Orator, with a highly rated commercially available synthesizer, listeners said Orator did a better job of pronouncing both words and names.

Most existing systems create speech using phonemes—the consonant and vowel sounds within a word. But Orator uses sound units that may contain several phonemes. Nearly 1,000 of these units—known as demisyllables, or half syllables—are stored in Orator's memory. By comparison, there are only 40 phonemes in the English language.

Bellcore developed its new software to help telecommunications companies deliver automated operator announcements and directory assistance. Correct pronunciation is especially important when communicating names and numbers, says Murray Spiegel, a staff member on the Orator project.

Orator might eventually be used to create personalized announcements in an electronic mail system, or to deliver directory-assistance messages that would include names, addresses, and phone numbers.

Serious note for Nintendo

Attach Software Toolworks' electronic keyboard to your Nintendo video game via its game port, slide in the special Miracle Piano Teaching System program cartridge, crack your knuckles (very important), and get ready to learn to play the piano. First the artificial intelligence determines your present melodic skills, then the teaching system creates custom lessons on the TV screen for you to follow on the keyboard. And as you progress, the system increases the skills required.

It worked? You're now a pianist? Then detach the keyboard. It has built-in speakers for solos, it's MIDI-compatible for use with other instruments or computers, and its keys are velocity sensitive for full piano expression. Price: the cost of a few piano lessons —$300 from The Software Toolworks (19808 Nordhoff Pl., Chatsworth, Calif. 91311).

No other training—in school, on the job, anywhere—shows you how to troubleshoot and service computers like NRI

HARD DISK
20 megabyte hard disk drive you install internally for greater data storage capacity and data access speed.

NEW! AT-COMPATIBLE COMPUTER
High-speed 80286 CPU (12 MHz clock, 0 wait states), 1 meg RAM, 1.2 meg, 5¼" high-density floppy disk drive.

DIGITAL MULTIMETER
Professional test instrument for quick and easy measurements.

MONITOR
High-resolution, non-glare, 12" TTL monochrome monitor with tilt and swivel base.

LESSONS
Clearcut, illustrated texts build your understanding of computers step by step.

TECHNICAL MANUALS
With professional programs and complete specs on your computer.

DIGITAL LOGIC PROBE
Simplifies analyzing digital circuit operation.

SOFTWARE
Including MS-DOS, GW BASIC, word processing, database and spreadsheet programs.

DISCOVERY LAB
Complete breadboarding system to let you design and modify circuits, diagnose and repair faults.

Only NRI walks you through the step-by-step assembly of a powerful AT-compatible computer system you keep—giving you the hands-on experience you need to work with, troubleshoot, and service all of today's most widely used computer systems. You get all it takes to start a money-making career, even a business of your own in computer service.

No doubt about it: The best way to learn to service computers is to actually *build* a state-of-the-art computer from the keyboard on up. As you put the machine together, performing key tests and demonstrations at each stage of assembly, you see for yourself how each part of it works, what can go wrong, and how you can fix it.

Only NRI—the leader in career-building, at-home electronics training for more than 75 years—gives you such practical, real-world computer servicing experience. Indeed, no other training—in school, on the job, *anywhere*— shows you how to troubleshoot and service computers like NRI.

You get in-demand computer servicing skills as you train with your own AT-compatible system—now with 20 meg hard drive

With NRI's exclusive hands-on training, you actually build and keep the powerful new AT-compatible West Coast 1010 ES computer, complete with 1 meg RAM and 20 meg hard disk drive.

You start by assembling and testing the 101-key "intelligent" keyboard, move on to test the circuitry on the main logic board, install the power supply and 1.2 meg 5¼" floppy disk drive, then interface your high-resolution monitor. But that's not all.

Only NRI gives you a top-rated micro with complete training built into the assembly process

Your NRI hands-on training continues as you install the powerful 20 megabyte hard disk drive—today's most wanted computer peripheral—included in your course to dramatically increase your computer's storage capacity while giving you lightning-quick data access.

Having fully assembled your West Coast 1010 ES, you take it through a complete series of diagnostic tests, mastering professional computer servicing techniques as you take command of the full power of your computer's high-speed 80286 microprocessor.

In no time at all, you have the confidence and the know-how to work with, troubleshoot, and service every computer on the market today. Indeed you have what it takes to step into a full-time, money-making career as an industry technician, even start a computer service business of your own.

No experience needed, NRI builds it in

You need no previous experience in computers or electronics to succeed with NRI. You start with the basics, following easy-to-read instructions and diagrams, quickly moving from the fundamentals to sophisticated computer servicing techniques. Step by easy step, you get the kind of practical hands-on experience that makes you uniquely prepared to take advantage of every opportunity in today's top-growth field of computer service.

What's more—you learn at your own pace in your own home. No classroom pressures, no night school, no need to quit your present job until you're ready to make your move. And all throughout your training, you have the full support of your personal NRI instructor and the NRI technical staff always ready to answer your questions and give you help whenever you need it.

Your FREE NRI catalog tells more

Send today for your free full-color catalog describing every aspect of NRI's innovative computer training, as well as hands-on training in robotics, video/audio servicing, electronic music technology, security electronics, telecommunications, and other growing high-tech career fields.

If the coupon is missing, write to NRI School of Electronics, McGraw-Hill Continuing Education Center, 4401 Connecticut Avenue, Washington, DC 20008.

AT is a registered trademark of International Business Machines Corporation

NRI School of Electronics
McGraw-Hill Continuing Education Center
4401 Connecticut Avenue, Washington, DC 20008

For career courses approved under GI bill
☐ check for details

☑ **Check one FREE catalog only**

☐ **Computers and Microprocessors**
☐ Robotics
☐ TV/Video/Audio Servicing
☐ Computer Programming
☐ Security Electronics
☐ Electronic Music Technology
☐ Basic Electronics
☐ Telecommunications

Name (please print) Age

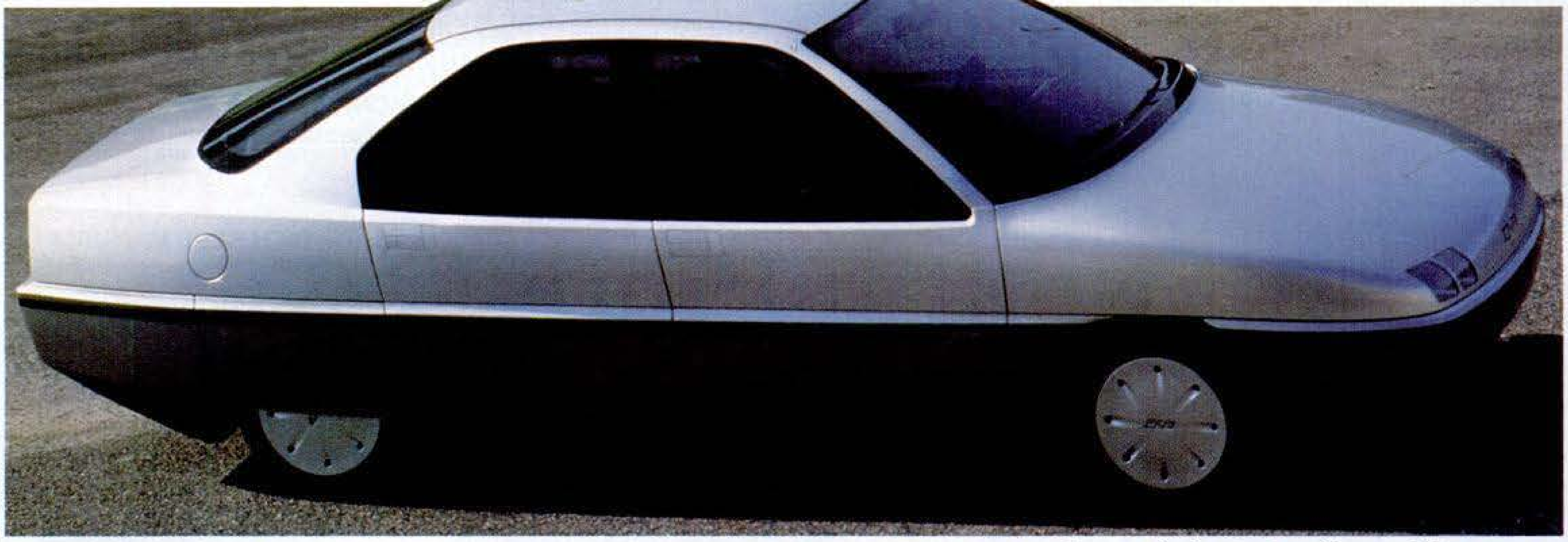
Address

City/State/Zip

Accredited Member, National Home Study Council 101-080

Automotive Newsfront

By **DAN McCOSH** Detroit Editor *with Brian Nadel, David Scott in London, and Marcelle M. Soviero*



Flush windows and door handles, and a gently sloping hood and trunk help the Pininfarina CNR E2 achieve a sleek 0.193-coefficient-of-drag rating.

Slipperiest design yet

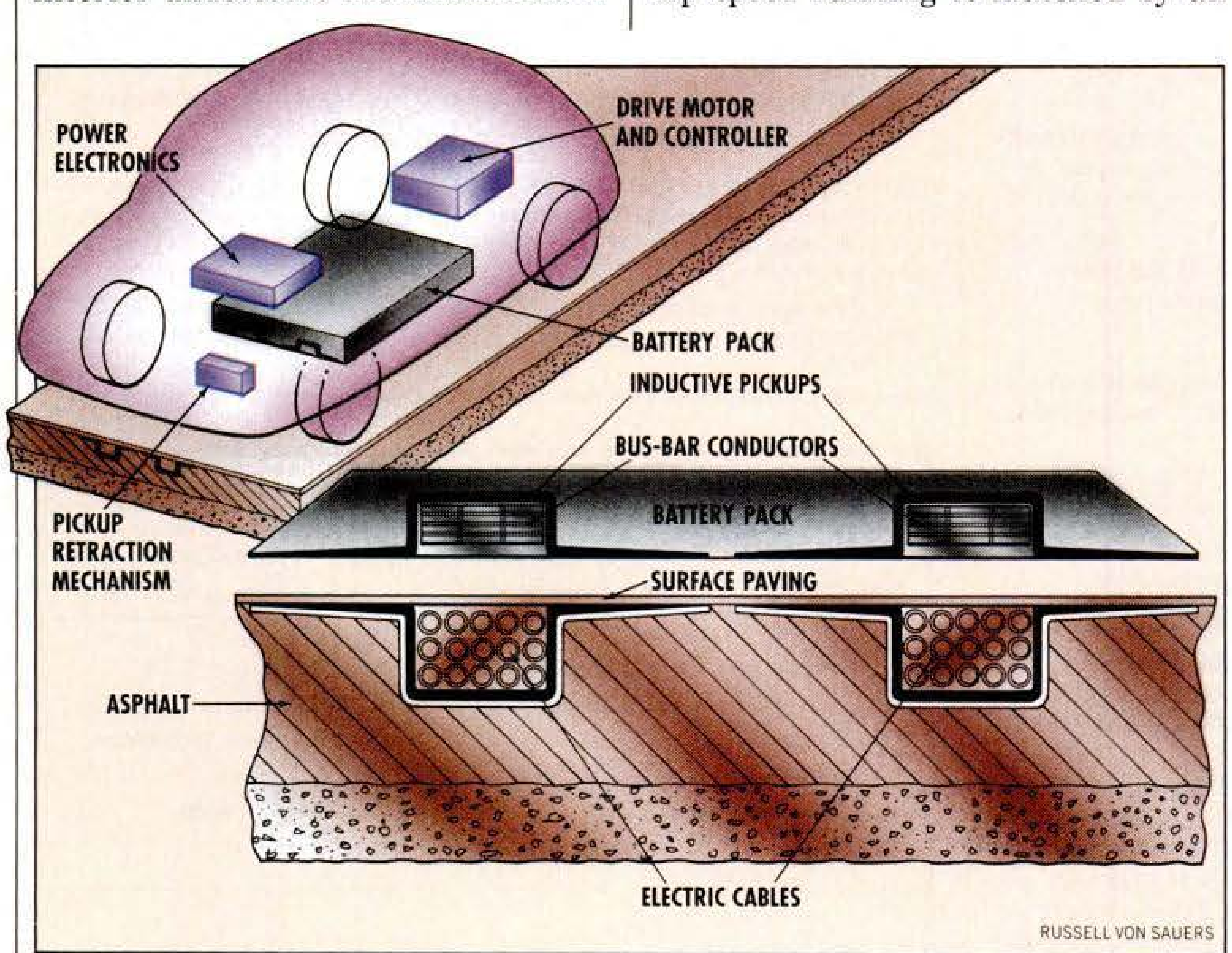
After four years of research, Italian stylist Sergio Pininfarina has come up with the slipperiest real-world car design seen so far. The CNR E2 prototype shown at the Turin car show is an aerodynamic step forward with an astounding 0.193-coefficient-of-drag rating. But unlike the products of most design studios, it is a real road runner. The CNR E2's placid lines and roomy interior underscore the fact that it is ready for mass production without major modification, though a name to match the body's flowing lines couldn't hurt.

Fiat assisted Pininfarina with construction of the prototype, which uses mechanical components from Fiat's Tipo. The 2,160-pound five-passenger sedan can slice through the air at 127 mph propelled by only 78 horsepower from its 1.4-liter four-cylinder engine, according to Pininfarina. Such efficient top speed running is matched by an exceptionally low thirst for gasoline: 52.2 mpg at 55 mph and 42.7 mpg at 72 mph.

The 15-foot-long sedan is the result of a 12-year joint project between the Turin-based Pininfarina design studio and the Italian National Research Council. (CNR is the Italian acronym for this organization.) The initial outcome was a sausagelike creation with a retracted underbelly, whose odd appearance was matched only by its extraordinary 0.172-Cd rating for the wind-tunnel model; Pininfarina designers estimated a 0.203-Cd rating for a road-going version. Popular Science featured this car on its November 1979 cover. The CNR E2 improves on this with a pleasing shape that benefits from a rounded nose, a low tapered tail, and a roof line that blends smoothly with the rear window and trunk lid. Attention to aerodynamic detail is typified by flush door handles—a fingertip push against the lower hinged rectangle just below the window line gives access to the catch.

Slot-car roadway

The disappointing range and performance of electric cars to date has done little to increase acceptance of these low-polluting alternatives to conventional gasoline-powered automobiles. Indeed, when General Motors began work on its Impact electric two-seater, performance comparable with mass-produced sports cars was considered vital for the project to succeed. But the present state of battery develop-



RUSSELL VON SAUERS

Electricity to power a vehicle can be provided by cables hidden beneath the highway. Power is transmitted inductively to a magnetic pickup on the underside of the electric car.

ment makes this hard to accomplish.

The solution may be a full-sized version of miniature slot cars that draw their power from the road. Southern California Edison Co. and the Los Angeles Department of Water and Power have teamed up to demonstrate the viability of roadway powered electric vehicles (RPEV).

Cars, or for this experiment two electric vans and a commuter bus, will draw all the current needed for highway cruising from cables buried in the road. To minimize the hazard from electrocution, there are no exposed wires and no direct electrical connection between the roadway and the car. Power is transmitted to the car by means of magnetic induction, not conduction. The energy transfer occurs in much the same manner as an air core transformer: A magnetic field emitted from current-carrying cables just below the pavement induces a current flow in the car's magnetic pickup (see drawing). To keep the power transmission efficiency above 90 percent, the pickup must ride between 1.5 and 3.5 inches above the pavement. From there, the electricity flows through control electronics to the electric drive motor. Any current not immediately needed for the motor is used to charge the batteries.

Assuming a world of interconnected RPEV roadways, the major advantage is that electric cars could rely on these wired roadways and be able to carry smaller, lighter battery packs, essentially for getting to and from the electrified highways. In the Los Angeles basin, where the test is being conducted, the average distance to a freeway entrance is just two miles, so most electrified commutes or shopping trips would be almost fully powered by the electrified road.

The down side is the price. The 1,000-foot-long Playa Vista demonstration project is estimated to cost $2 million, and estimates for commercial electrified roadways are $1.5 million per mile. Multiply that by 12,000 lane miles of freeways between Los Angeles and San Diego and the cost is staggering. To get the clean air afforded by remotely powered electric highways, Californians may just have to give up their coveted no-toll freeways.

Viper takes off

The rough-and-ready Viper sports car project got the final go-ahead ["ANF," July] from Chrysler executives, product planners, and accountants. The present plan is for a 1993 debut. Viper will be powered by an all-aluminum 400-hp seven-liter V10 engine. Chrysler plans to begin by building between 200 and 500 of the special-edition vehicles, a volume small enough not to affect the company's corporate average fuel economy rating.

Electronic shocks

A new high-strength linear electric actuator that produces up to a ton of force was shown recently to Detroit engineers. Designed by Aura Systems of El Segundo, Calif., the long-stroke, high-strength actuators are a promising alternative for power steering and even suspension systems, according to Aura engineers.In effect, the actuators are linear electric motors: Rather than creating rotational motion, the motor will push or pull a long rod in a straight line. Thin section coils, constructed of flattened strips of aluminum, contribute to the electrical efficiency of the units. Aura engineers say the first product using this actuator could be an active suspension system.

Taking microchips for a ride

Truck tires may contain something more than rubber and cord these days—an electronic microchip system capable of keeping track of the tire and its maintenance and performance history. The batteryless transponder, developed by Destron/IDI of Boulder, Colo., is a passive device that sits inside the tire. At the heart of the sys-

FINALLY, THE CAPRI

PREVIEW DRIVE

There is a stretch of mountain road east of San Diego on which it is impossible not to like an open-top car, whether it be a sun roof, a T-top, a Volkswagen Beetle with the top folded back, or a chop-top pickup truck. On this road the new 1991 Lincoln-Mercury Capri excels.

The base Capri features a twin cam 1.6-liter Mazda engine rated at an even 100 horsepower. But it is the 132-hp turbocharged version of the XR2 that really lights up the tires, pulling to 60 mph in about eight seconds, nearly matching the performance of the heavier five-liter V8-powered Ford Mustang GT. Capri's fully independent suspension is solid, stable, and predictable, grooving solidly into corners without effort. The responsiveness makes it virtually impossible to guess that this is a front-wheel-drive car.

Curiously, while the Capri compares favorably against most soft-top sports cars and the new generation of reincarnated roadsters—including the Mazda Miata—it fares poorly against its own promises.

The Capri is the final production version of a car that first tempted the imagination at the 1983 Frankfurt motor show. The car's debut was as the Ghia-designed Barchetta, and it was based on a Ford Fiesta chassis. The stubby, aggressive design was strongly reminiscent of the Porsche speedster. Later versions gradually became longer and more subdued, as the program progressed through product clinics and sourcing decisions. After an elephantlike gestation period, the Capri that finally emerged is a combination of seriously tuned suspension and relatively high power.

The interior is functional, though marred by styling that favors the sedan set over functional designs of the past. The Capri does offer considerably more interior room than most of its competition, however, and it is therefore able to put the driver and passenger in more comfortable seating positions.

In testimony to the international nature of the automobile business these days, Ford ultimately decided to build the Capri in Australia based on the last generation Mazda 323 platform. A bolt-on hardtop, an extra-cost option, considerably stiffens the body structure, though the car still exhibits some shake over rough roads. Extra stiffening is used in the rear body area to allow the use of the pass-through door between the rear seat and trunk. All in all, the finished Capri is a more useful, but less exciting car than Ford originally promised. —*D. M.*

tem is a radio frequency identification circuit that is activated by an external, wandlike reader. A wave of the electronic wand over the tire yields its unique identification number, which in the central computer is matched up with the tire's history. Archival data can include: date of manufacture, when it was retreaded or repaired, and just about any tire-based trivia wanted. Because the wand's range is between six and twelve inches, this system is not able to track or locate missing tires or vehicles.

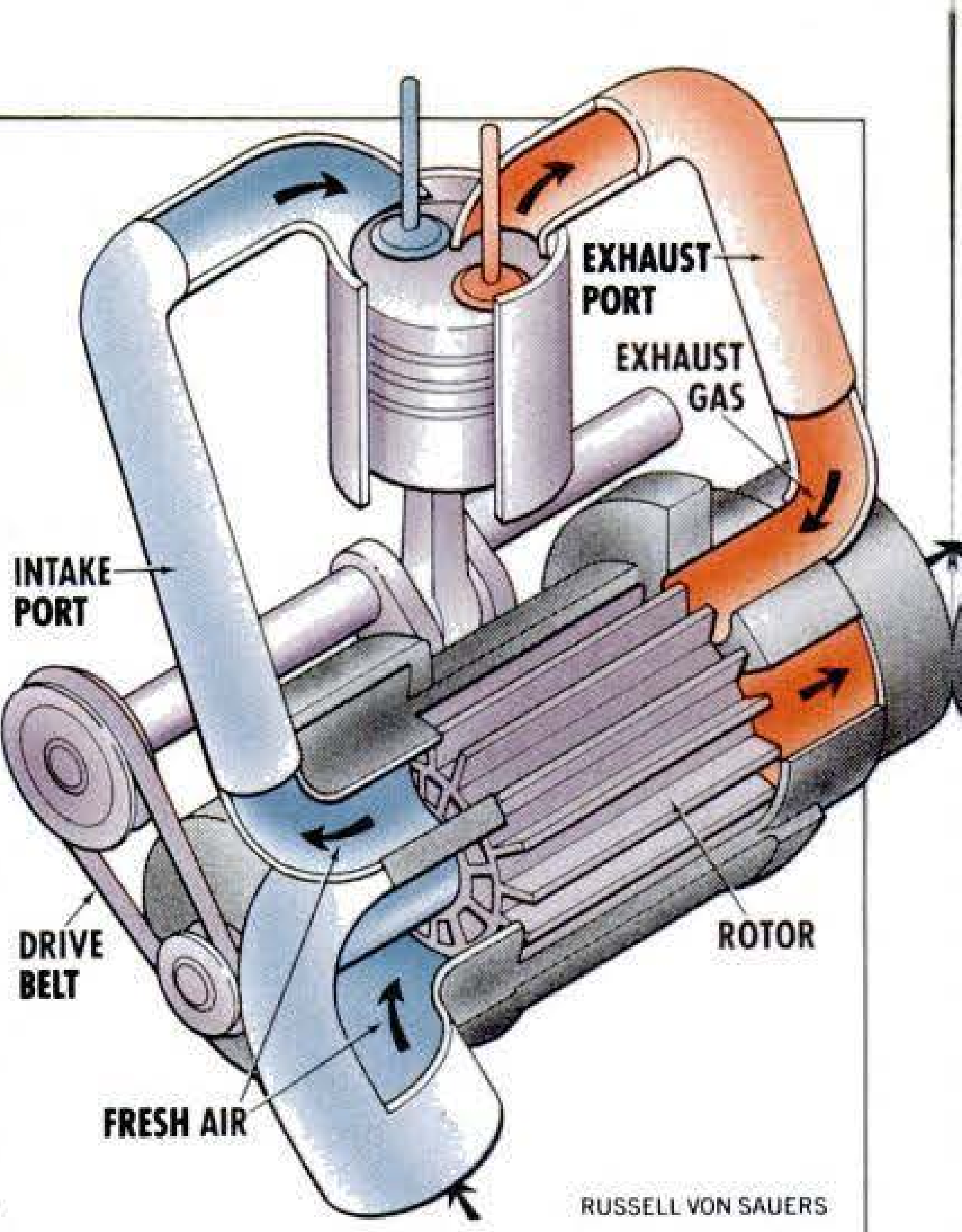
To protect the fragile chip from the harsh environment encountered on the inside of a truck wheel, it is wrapped in a rubber envelope that was developed by Patch Rubber Co. of Roanoke Rapids, N.C. This gives the microchip an advantage over other identification techniques such as sidewall bar coding or branding because the electronically stored information is safe and sound in a computer and cannot be obscured, claims the manufacturer. The rubber envelope allows the microchip to be attached directly to the tire. "You just remove the tire from the rim and put the chip inside," says Carl Peterson, market manager for industrial products at Destron/IDI.

Keeping tire records in this way may sound tedious to the typical car owner with four or five tires to track. But for a fleet of trucks with many thousands of tires to monitor, this sort of device helps the bottom line. "A tire's carcass is a valuable commodity," says Peterson. "You want to make sure you have a repair record and a performance history." The $8 chip is designed to operate throughout a tire's life, which, with retreadings, could add up to several hundred thousand miles.

Mazda compressed

Pressure-wave supercharging gets a boost from a new joint venture between Japan's Mazda and Switzerland's Asea Brown Boveri Ltd. The Swiss company developed a new concept in supercharging that Mazda currently uses on the two-liter diesel engine Capella (the Japanese-market equivalent of the 626 model).

The Comprex system (for compression and expansion) uses a rotary drum that compresses intake air with the energy from exhaust gas pulses. The device routes hot exhaust gas through the drum in one direction and fresh air in the other. When the two streams meet, pressure is equalized, in effect boosting the intake air, at the expense of the cooled and depressurized exhaust flow. This transfer of energy not only



Cool, fresh intake air is boosted as it meets a stream of hot exhaust gas in the rotating drum of the Comprex supercharger.

The First Component Music System You Can Take Seriously. Anywhere.

The drivers used in Model Eleven's two-way satellite speakers are no-compromise, high-performance components–just like you'd expect to find in the finest home speaker systems.

Model Eleven™ is the first *transportable* high performance component music system. It consists of a powerful 3-channel amplifier and two "satellite" high-frequency speakers–all packed in a "BassCase"™ that, when empty, serves as the system's subwoofer. Model Eleven's performance, when coupled with your portable CD or tape player, rivals that of the most expensive component systems. And because we market it directly from our factory, it costs hundreds less than it would in stores.

Model Eleven's three speakers are designed to work *with* a room's acoustics to create seamless, musically accurate sound virtually identical to our critically acclaimed Ensemble® speaker system.

And it can be used anywhere in the world–115- or 230-volts AC, or 12-volts DC. It fits under an airline seat (or can be checked as baggage) so you can take it anywhere. But Model Eleven's sound is so good, so "big," you may want to keep it home.

Try Model Eleven Risk-Free For 30 Days. Call 1-800-AKA-HIFI.*

Like all our products, Model Eleven is only sold factory direct...by helpful, experienced audio experts. So you can audition it the *right* way–in your home for 30 days, with no risk. At $599† we know of no music system near its price (transportable or not) that approaches its sound quality.

*9AM to midnight (ET), seven days a week. In Canada, call 1-800-525-4434. Fax: 617-332-9229. Outside the U.S. or Canada, 617-332-5936.

- Fits under airline seats.
- Can be checked as luggage.
- Works on all electrical systems.
- Delivers the full range of music.
- Is backed by a unique 5-year warranty.
- Makes an ideal Fathers' Day or Graduation gift.

© 1990 Cambridge SoundWorks. ® Ensemble is a registered trademark of Cambridge SoundWorks. ™BassCase, Ambiance, Model Eleven and Cambridge SoundWorks are trademarks of Cambridge SoundWorks, Inc.

CAMBRIDGE SOUNDWORKS
126AU 154 California St., Newton, MA 02158
☐ Send me more information on Model Eleven.
☐ Send Model Eleven risk-free for 30 days, for $599.†
☐ Send me information on other Cambridge SoundWorks products.
I'm paying by ☐ Check ☐ MC ☐ Visa ☐ AmEx
Acct. Number__________ Exp.____
Signature__________
Name__________
Address__________
City______ State___ Zip_____
Phone (Area Code)____ Number______
FOR IMMEDIATE SERVICE: 1-800-AKA-HIFI.
MA residents add 5% sales tax.
†Plus UPS freight $5–$14. Delivery time usually 2–7 days. Next day shipping extra. We ship worldwide, including APO & FPO.

Henry Kloss created the dominant speaker models of the '50s (AR), '60s (KLH) and '70s (Advent)–as well as our highly acclaimed Ensemble and Ambiance™ speakers. While packing a stereo system into a suitcase before a vacation, he realized that an amplifier, a CD player and two small speakers take up the same space required for an acoustic suspension woofer to reproduce really deep bass. That was the inspiration for BassCase, Model Eleven's bass speaker enclosure which doubles as the entire system's carrying case.

compresses the intake air, but heats it considerably, making intercooling a practical necessity.

While the drum is belt-driven, the energy for compression comes directly from the hot exhaust gas stream—which means little energy is tapped from the crankshaft, a major disadvantage of conventional supercharging. Extremely quick throttle response and low parasitic losses at high speeds are the advantages claimed for the system.

So far, the only commercial use has been on the Mazda diesel. Mazda engineers say that while diesels are more adaptable to Comprex supercharging (because they don't have any throttle plate interfering with the intake air) other possibilities exist. One area ripe for exploitation is the potential of using the rotating drum as a catalytic converter, anticipating the eventual need for catalysts on diesels as emission standards are tightened.

Fixing the GM plastic minivan

Rick Soles picks a ball-peen hammer from his worktable and gives the side of a blue Chevrolet Lumina APV minivan a few good whacks. Then he runs his hand along the impact area and describes the plastic body material as "very forgiving." Soles, the body-repair instructor at the General Motors Training Center in Tarrytown, N.Y., was demonstrating the plastic minivan's ability to bounce back from a slight run-in with a shopping cart. His rapt audience consisted of a group of bodyshop technicians and one curious reporter.

But for more severe impacts, Soles adds, the APV's plastic skin will not be all-forgiving. The repair technique for a major collision is different from conventional sheet-steel repair jobs, though not necessarily more complicated. For our class, Soles told us to imagine that the demonstration APV was hit in the rear driver's side, mangling the quarter panel below the rear window, tearing up the brake light and turn-signal assembly, but leaving the rear hatch and space frame undamaged. We started by slicing away the damaged area with a power saw, being careful not to nick or cut the steel space frame below. Once the outline was cut, we heated the epoxy glue used to bond the panels to the framework with a heat gun until it turned to the consistency of molasses, about 400 degrees F. The panel can then be pried away from the attachment points with a putty knife.

After clearing away the remaining glue, we cut a replacement piece from a full quarter panel and glued it into place with a two-part epoxy glue. With experienced body technicians and Soles supervising, the repaired panel was ready for paint prepping in just over two hours.

Why such an emphasis on teaching repair for a new vehicle? Says Soles: "We need to do these repairs now to gain experience and teach technicians so that when they encounter real-world problems they'll be ready to deal with them."

Marketing blunder?

Could Ford's marketing gurus in Dearborn, Mich., have goofed in 1985 when they brought the German-built Merkur to Lincoln-Mercury dealerships, where few American buyers expected to find a sophisticated European car? Without suitable promotion, Merkur sales never materialized, and last year the Scorpio, and its sporty companion XR4Ti, got the ax. Recently Ford of Europe launched a three-box notchback ver-

SMOOTH TOBACCO TASTE.
NO BURN.
NO BITE.
PREMIUM·LEAF
GRANGER SELECT
CHEWING TOBACCO
WARNING:
THIS PRODUCT MAY CAUSE GUM DISEASE AND TOOTH LOSS.
© The Pinkerton Tobacco Company, 1990.

sion of the Scorpio. After a week driving one on English motorways, country lanes, and in urban traffic, I think this luxury sedan could be snapping at the heels of the likes of Saab 9000, Audi 100, and even BMW's 5-Series.

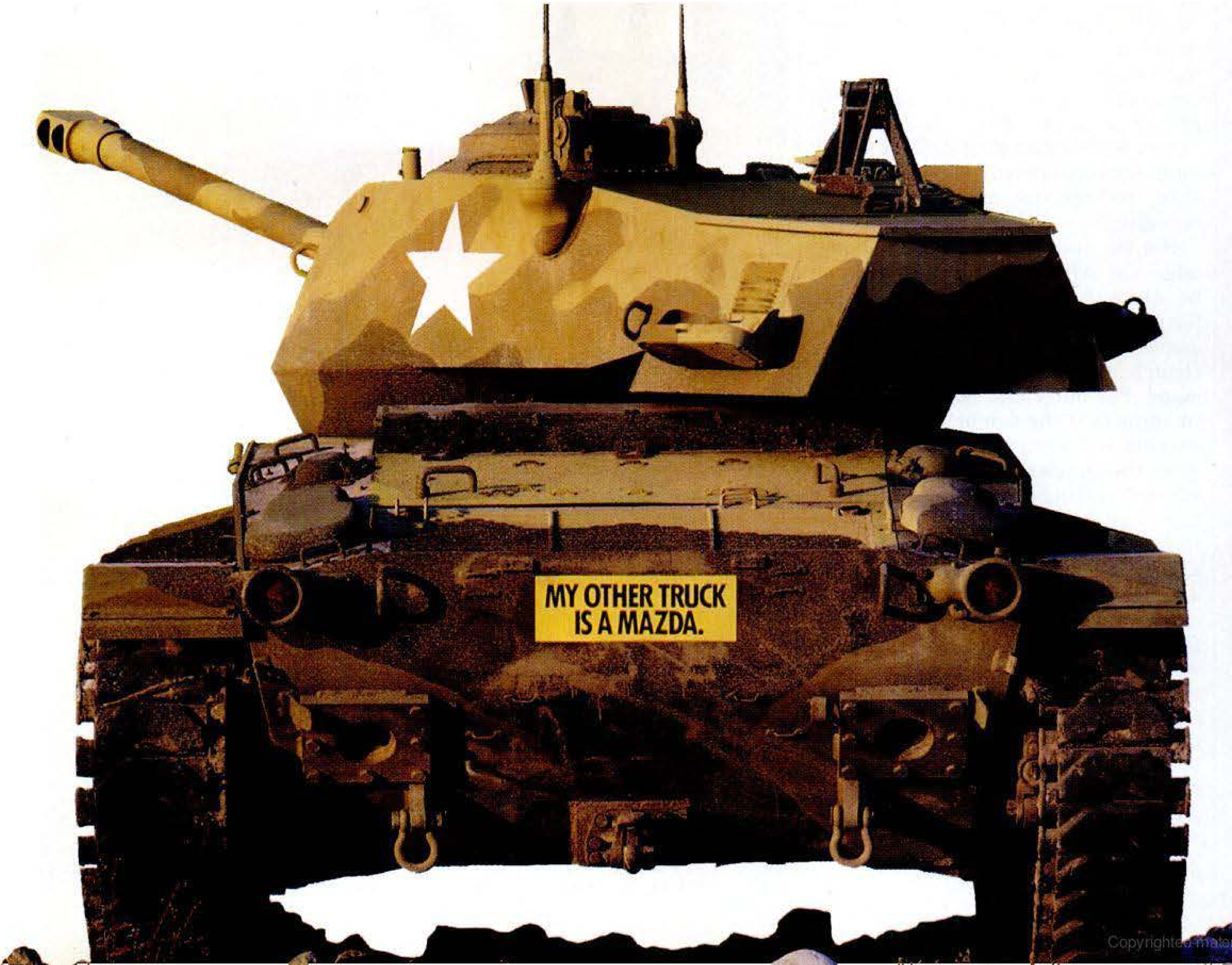
Ford's British Design Group did the body conversion, stretching the length by three inches to 186.6 inches to fashion the 17.3-cubic-foot trunk. The car is loaded with goodies befitting its status, including anti-lock disc brakes at each wheel, automatic self-leveling suspension with auxiliary air springs, and power everything.

I found the ride, handling, and noise levels difficult to find fault with. While the top engine is Ford's aging 2.9-liter pushrod V6 that delivers 145 hp (equipped with a catalytic converter), acceleration and speed seemed ample for a sedan of this class. The on-board computer calculated a United States equivalent of 22.7 mpg over 1,000 miles of varied driving. Though this is no fireball, an upcoming 24-valve V6 should make the Scorpio a match for the best Europe has to offer.

Maybe Dearborn should think again about the Scorpio.

SPORTY SPORT-UTILITY VEHICLE

As more confirmed car buyers switch to trucks for basic transportation, manufacturers are coming up with tame and more-pampered interpretations of the sport-utility vehicle. The Isuzu Costa concept vehicle that made its debut at the 1990 New York auto show demonstrates the California approach. The Costa's dimensions mimic those of the Isuzu Amigo: length, 167 inches; width, 70 inches. There's seating for four, but the rear two settle for a kind of rumble seat. The Costa is powered by the Amigo's 2.6-liter in-line four-cylinder engine rated at 120 horsepower. There are no production plans.—*B. N.*



NATURAL-GAS BUS

As part of the effort to reduce pollution, many municipal transit agencies are considering the use of compressed natural-gas-fueled buses. The fit seems natural: 90 percent lower carbon monoxide and 85 percent lower reactive hydrocarbon emissions compared with the typical diesel bus, and lower fuel and maintenance costs. But bulky steel storage tanks, which add 2,800 pounds to a 30,000-pound bus, limit range and performance. The three tanks at the right are made of aramid fiber wrapped around an aluminum core for a weight savings of 1,000 pounds. Following an extensive testing program by Flxible Corp. of Delaware, Ohio, the tanks were shown to meet or exceed safety standards and have been approved by the Department of Transportation. The next step is to replace the aluminum core with plastic for a further 500 pound savings.—*B. N.*

News briefs

- Unocal Corp., the West Coast refiner, will buy up to 7,000 of Los Angeles' most polluting pre-1971 cars. Sellers get $700 and a one-month bus pass.
- Honda of America has recently started building right-hand-drive versions of the 1990 Accord Coupe for export to Japan. Anticipated production: 12,000 units per year.
- Ford of Europe has recently installed what could be the world's most sophisticated automotive test facility. The Essex, England, test chamber can vary climate from tropical to arctic, while hydraulic rams at each wheel reproduce road surface and speed.
- Automobiles Citroën will finally end production of the long-running 2CV, the much-loved (by Frenchmen at least) two-cylinder minicar that made its debut in 1949.

How would it feel attacking dry washes, instead of merely surviving them? To literally plow through mud pits, rather than circle them? It would feel like a new Mazda Truck.

The compact pickup ranked the most trouble-free in America for the second straight year according to J.D. Power's Compact Truck Initial Quality Survey.* In fact, Mazda pickups also ranked highest in J.D. Power's Truck Customer Satisfaction Index.** A distinction it has earned four out of the past five years. Mazda trucks are also backed with the best basic warranty in the business: 36 months/50,000 miles "bumper-to-bumper."*** So come feel what it's like to hit the road in a 1990 Mazda Truck. Just about the toughest off-road vehicle you can drive, without going through boot camp.

mazda

IT JUST FEELS RIGHT.℠

*J.D. Power and Associates 1989 and 1990 Compact Truck Initial Quality Survey.℠ Based on owner reported problems during the first 90 days of ownership.
**J.D. Power and Associates 1990 Light-Duty Truck Customer Satisfaction with Product Quality and Dealer Service.℠ (Compact Pickup Ranking: '86 through '88 and '90 CSI Studies.)
***See your Mazda Dealer for limited-warranty details. © 1990 Mazda Motor of America, Inc.

Home Newsfront

By V. ELAINE GILMORE *with Mariette DiChristina and Judith Anne Yeaple*

Photovoltaic panels supply all the electricity for this otherwise conventional tract house in Florida. Batteries take over when the sun's not out.

Sun power to the people

A builder in Florida is selling tract houses with a difference: They produce their own electricity from photovoltaic panels mounted on the roof.

Most PV-equipped houses to date have been either primitive hideaways or pricey custom jobs. Indeed, this builder, the Charles Wayne Group in Lake Placid, Fla., built one of the latter about three years ago. Called Powerhouse I, it was strictly for research, development, testing, and show. "But if it were for sale, it would go for $300,000—without the solar features," says J. Wayne Beighle, executive vice president of the company.

Now, with Powerhouse II, the company has taken its most popular tract house, added the solar package, and come out with a 2,480-square-foot model that it will duplicate anywhere in northern or central Florida for $170,000. (You supply the lot.) The solar components account for $63,000 of the price.

The photovoltaic panels are made by Kyocera America, a huge Japanese electronics company. One hundred eight of the polycrystalline PV panels, each rated at 59 watts, are mounted on a motorized roof rack. A computer sees to it that their iridescent blue faces point east at sunrise, then follow the sun across the sky. The solar cells are about 13 percent efficient.

Batteries store enough energy to see the house through five cloudy days. All of the appliances are electric except for the range and clothes dryer, which use propane. A heat pump provides cooling in summer, heating in winter, and hot water year-round. It has been modified to use the direct current produced by the PV cells and batteries. All the other appliances are conventional: A pair of inverters change the DC to AC.

"If you assume that eighty percent of the purchase price of the house (with lot) is financed at ten percent, and you were to apply the $200 a month you'd save in electric bills to paying off the mortgage, you'd be able to pay back a thirty-year mortgage in eighteen years," Beighle says. Savings would be more than $58,000 (that assumes no escalation in electric rates). The PV panels are expected to last more than 20 years, and the batteries at least 10.

So far, two home buyers have signed up for sun power.

New low-e glass

Low-emissivity windows have soared in popularity since their introduction a decade ago. Today they account for 30 percent of new residential windows sold. Now a third-generation low-e glass has been introduced by Libbey-Owens-Ford (LOF). Called Energy Advantage, it could make low-e windows even more popular.

"Emissivity" refers to the heat-emitting (or radiating) propensity of a surface. Only heat that is absorbed can be emitted, so the lower the emissivity number, the less heat absorbed —and conversely, the more reflected.

The purpose of a low-e coating on a window pane is to keep the long-wave infrared energy inside a room from passing out through the glass. Much of the incoming solar energy, however, can still pass through the coating, as can most of the visible light.

Though the term low-e glass is used generically, there are actually two types of coatings used ["Superwindows," March '86]. The original kind, called a sputtered, or soft, coat, is a layer of metal that is applied to the glass an atom at a time in a vacuum chamber. The result is glass with impressively low emissivity numbers (generally ranging from 0.05 to 0.15). But the sputtered coating is easily damaged. And the glass can be used only in multi-pane windows with the coating inside the sealed space.

The second type of low-e coating is called a pyrolytic, or hard, coat. A hard coat, typically tin oxide, is applied to the glass while it is still hot. The

"ADVERTISEMENT"

EXCITING NEW LAB TESTS HAVE CONFIRMED SLICK 50'S BENEFITS!

Save Gas, Save Engine with 'POLY'

WHAT IS POLY? "Poly" is short for polytetrafluoroethylene (TFE). It is the slipperiest substance known to man. **The 1989 Guinness Book of World Records (pg. 184) says:** *"The lowest coefficient of static and dynamic friction of any solid is 0.02, in the case of Polytetrafluoroethylene - equivalent to wet ice on ice. It was first manufactured in quantity by E.I. duPont in 1943, and is marketed as Teflon™."*

Slick 50 Engine Treatment will bond slippery "poly" to your engine for a minimum of 50,000 miles. **Unlike some temporary products** on the market, there is no need to add Slick 50 at every oil change. Exciting new lab tests have shown that Slick 50 Engine Treatment did indeed increase gas mileage and horsepower, and it reduced engine wear.

Slick 50's credentials are impressive

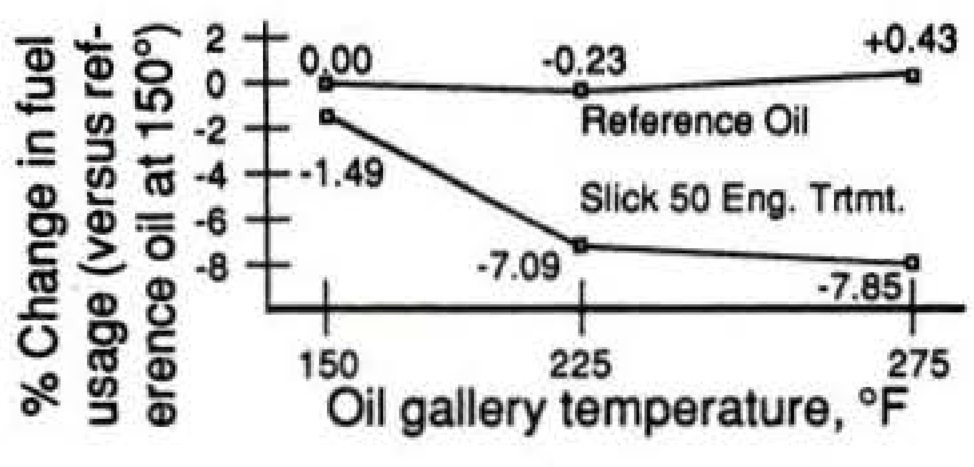
"Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicate that it will improve gas mileage by about two or three miles per gallon...Slick 50 does exactly what PetroLon claims it does." Consumers Digest, (March/April 1982, p.35)

In 1989, the premiere engine and lubricant testing lab in the U.S. tested Slick 50. This EPA recognized lab conducted a strictly controlled experiment using industry standard ASTM procedures. Results showed that Slick 50, compared to a standard reference oil, reduced engine wear **by more than 50%. Be cautious of those Poly treatments** that cannot back up their claims with such solid evidence.

In a fuel usage test conducted by this same prestigious lab, results showed that Slick 50 (compared to a standard reference oil at 150°) reduced fuel consumption in the test engine by **7.09%** at an oil temperature of 225° and **7.85%** at 275°. Once warmed up, most cars operate within the range of 225° to 275°.

Especially interesting is the fact that fuel usage with just the reference oil **increased** (see graph) as the oil got hotter than 225°. This is due to the well known fact that oil gets thinner at higher temperatures causing increased friction **(and wear)** in your engine. However with Slick 50, fuel usage actually **decreased** showing that **Slick 50 produced it's greatest friction reducing benefits at higher temperatures which is exactly when your engine needs it the most.**

As with any lab test, these results may not translate exactly the same percentagewise for every engine under every type of driving condition in the "real world". However the conclusion for these test cases is clearly that Slick 50 does reduce engine wear and does increase gas mileage.



FREE
DURALT FC
Mileage
Booster
SLICK
50
P.T.F.E. ENGINE TREATMENT
UNIQUE ONE TIME TREATMENT
FOR GAS AND DIESEL ENGINES

The Federal Aviation Administration has fully accepted a similar product - Slick 50 Aircraft Treatment (F.A.R. #33.49).

A test done at the **San Diego State University** revealed that, "Slick 50 does increase horsepower and decreases fuel consumption in tests done at the university". **TUV, a prestigious German testing laboratory,** tested Slick 50 and found a substantial increase in both gas mileage and horsepower. The **Space Shuttle Columbia** uses the chemical "Poly" in its gears and bearings because it is the only chemical lubricant which can withstand the heat and corrosive elements of space.

The Cranfield Institute, known worldwide for it's work in tribology (the study of friction) concluded a five year study on Slick 50 in 1989. Results showed that Slick 50 **did indeed coat metal surfaces, dramatically reducing friction and extending the life of the metal.**

Perhaps the most dramatic of all is a torture test seen by thousands of viewers on NBC TV station KPRC. A Lincoln Town Car was treated with Slick 50. During the broadcast, the oil was drained and the car was driven without the oil plug for about half an hour. The water temperature never rose and the engine sustained no apparent damage.

How do you give an engine a "Poly" treatment? Very simply! Change oil and filter and substitute one quart of Slick 50 for the last quart of oil. (Add two quarts for engines with oil capacities of seven quarts or more.) Slick 50 is excellent for all gas and diesel engines (even turbocharged and rotary engines).

Slick 50 will work with all petroleum based oils and synthetics compatible with petroleum based oils.

7 MONEY SAVING BENEFITS

Slick 50 has been thoroughly tested both by lab experts and by our customers on the road. These tests have shown that Slick 50 can:

1. Increase gas mileage.
2. Increase horsepower (small economy cars and large RV's really need this).
3. Make starting easier.
4. Reduce operating temperatures, thus increasing the life of the oil and engine.
5. Help make up for lubrication losses from new unleaded gasolines.
6. Provide a possible safety margin in the event of sudden oil pressure loss.
7. Minimize or eliminate costly overhauls by reducing engine wear. Up to 90% of engine wear is caused by lubrication starvation cars experience when first started before the oil begins to circulate. With Slick 50 the internal engine parts are protected even while the rest of your car's oil is still settled down in the sump. **All these benefits cost only as much as a couple of tanks of fuel.**

Will Slick 50 harm my engine or affect my warranty? No! The carrier oil for Slick 50 meets, or exceeds, every manufacturer's engine warranty requirements and carries an API service classification SG-CD.

More Slick 50 products are available.
A FREE catalog sent on request.

DOUBLE GUARANTEE!

Guaranteed lowest price and guaranteed satisfaction. If at the time of purchase you have seen Slick 50 advertised in a current magazine at a lower price, we will beat that price by $2.00 a quart. If you are not satisfied with our Slick 50, within 4 months, send us a note and proof of purchase for a full refund of purchase price. This makes trying Slick 50 **RISK FREE** to you.

DEALERSHIPS AVAILABLE

Free DURALT® Fuel Conditioner sent with each order. Free shipping with orders of 2 or more.

Call toll free 1-800-227-5425
Or send to:

★★★★★★★★★★★
U.S. AUTO-TECH™
INNOVATIONS & TECHNOLOGY
FOR PERFORMANCE MOTORING

407 Del Rio Road, Berthoud CO 80513

PS8

☐ I enclose $39.95 + $4 shipping for one qt.
☐ Send me ______ qts. of Slick 50 @ $39.95 ea.
FREE shipping (2 or more).
☐ Check ☐ C.O.D. ☐ VISA/MC/DISCOVER

Card#______________________________Exp.____

Name__________________________________

Address________________________________
(Give Street Address for U.P.S. Delivery)

City___________________________________

State___________________Zip____________

Teflon is a registered trademark of E.I. du Pont; Slick 50 of Petrolon; and Duralt of Polar Molecular Corporation resulting baked-on finish is durable, so the glass needs no special handling. But hard-coat low-e glass has a higher emissivity (generally in the 0.35 to 0.40 range). In addition, it sometimes has a bluish or purplish cast.

LOF's new Energy Advantage is a hard-coat low-e glazing with all the durability of other hard coats, but with an emissivity of 0.20—nearly as low as that of soft-coat products.

Energy Advantage glazing, like older hard coats, uses tin oxide as the coating material, says Tony Clark, product manager of residential products at LOF. The trick, he says, is in the application. The thicker the tin oxide coating, the lower the emissivity. "But the thicker coatings tend to have patches where you see a faint tint," he says. What LOF has done is to develop a method of applying a thicker coating more uniformly, which totally eliminates those bluish and purplish patches. The specifics, though, are proprietary.

Taken for granite

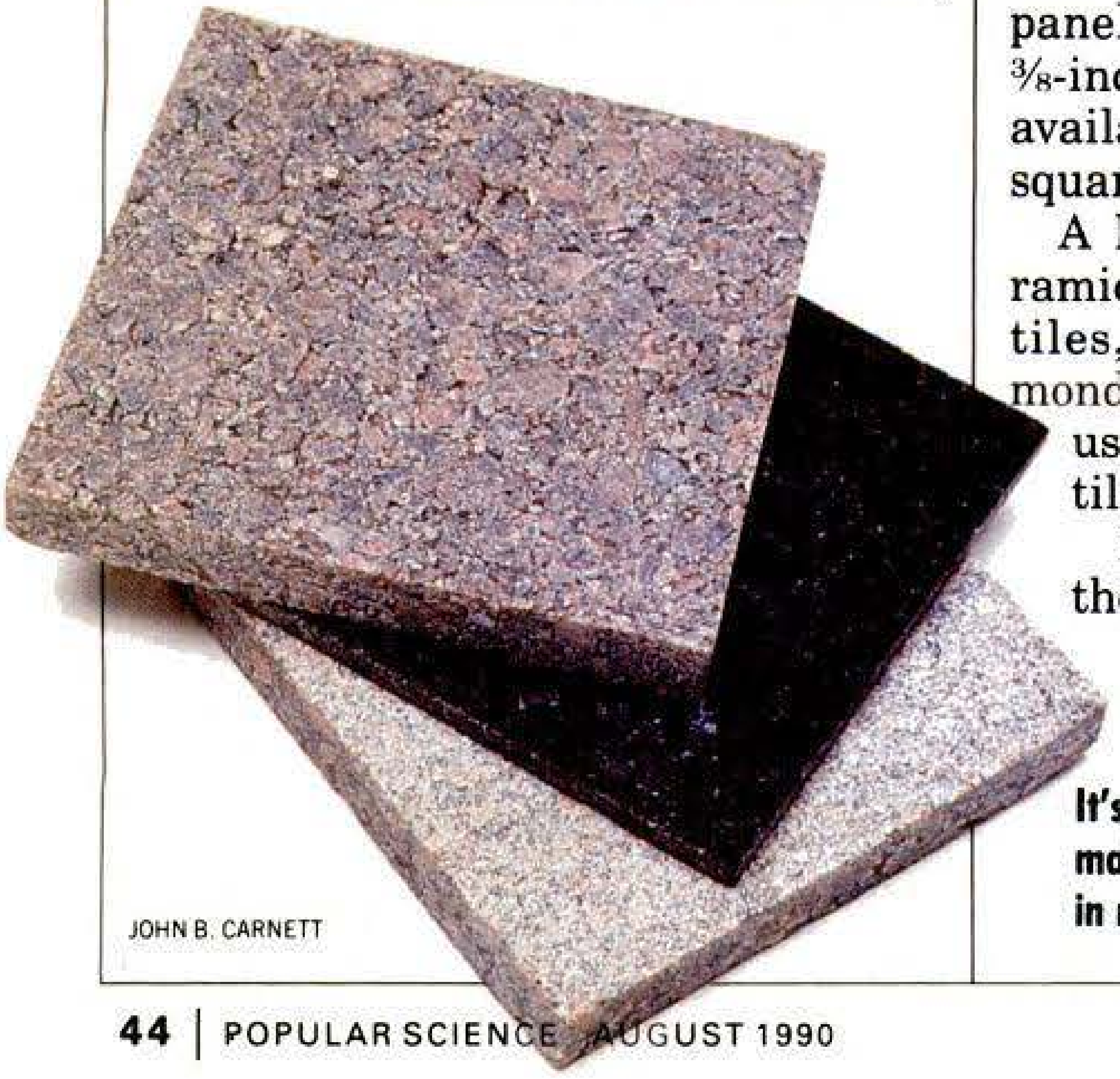
It looks like granite, it wears like granite, and indeed it is more than 90 percent granite. But unlike natural granite, this man-made version, called Granitech, comes in panels up to four by eight feet. It also weighs about half what granite weighs, and is more impact resistant and easier to work with, the maker claims. Most remarkable: Granitech is available as a ⅛-inch flexible veneer. When heated to 110 degrees F, you can curve these sheets to a minimum radius of 14 inches.

Granitech panels are crushed granite cast in a proprietary resin using a proprietary process. Both the resin and the process were developed by Christopher T. Banus, an industrial chemist and founder of The Granitech Corp. in Fairfield, Iowa.

Granitech can be used on walls, counter tops, floors, and furniture. It comes with either a polished, a honed (smooth matte), or a textured surface and in eight standard colors. Several panel sizes are available in ⅛- and ⅜-inch thicknesses. Granitech is also available as ⅜-inch-thick floor tiles in squares of 12, 16, and 24 inches.

A homeowner who can install ceramic tiles also can install Granitech tiles, the company claims, but diamond-tipped bits and blades should be used to cut the material. Granitech tiles cost $10 to $12 per square foot.

Panels, too, can be installed by the homeowner, but they are generally installed by a granite/marble fabricator. Even with professional installation, Granitech costs about 25 percent less than granite, the company notes.


JOHN B. CARNETT

It's real granite but Mother Nature didn't make it. Granitech is granite aggregate cast in resin. One type available: a flexible veneer.

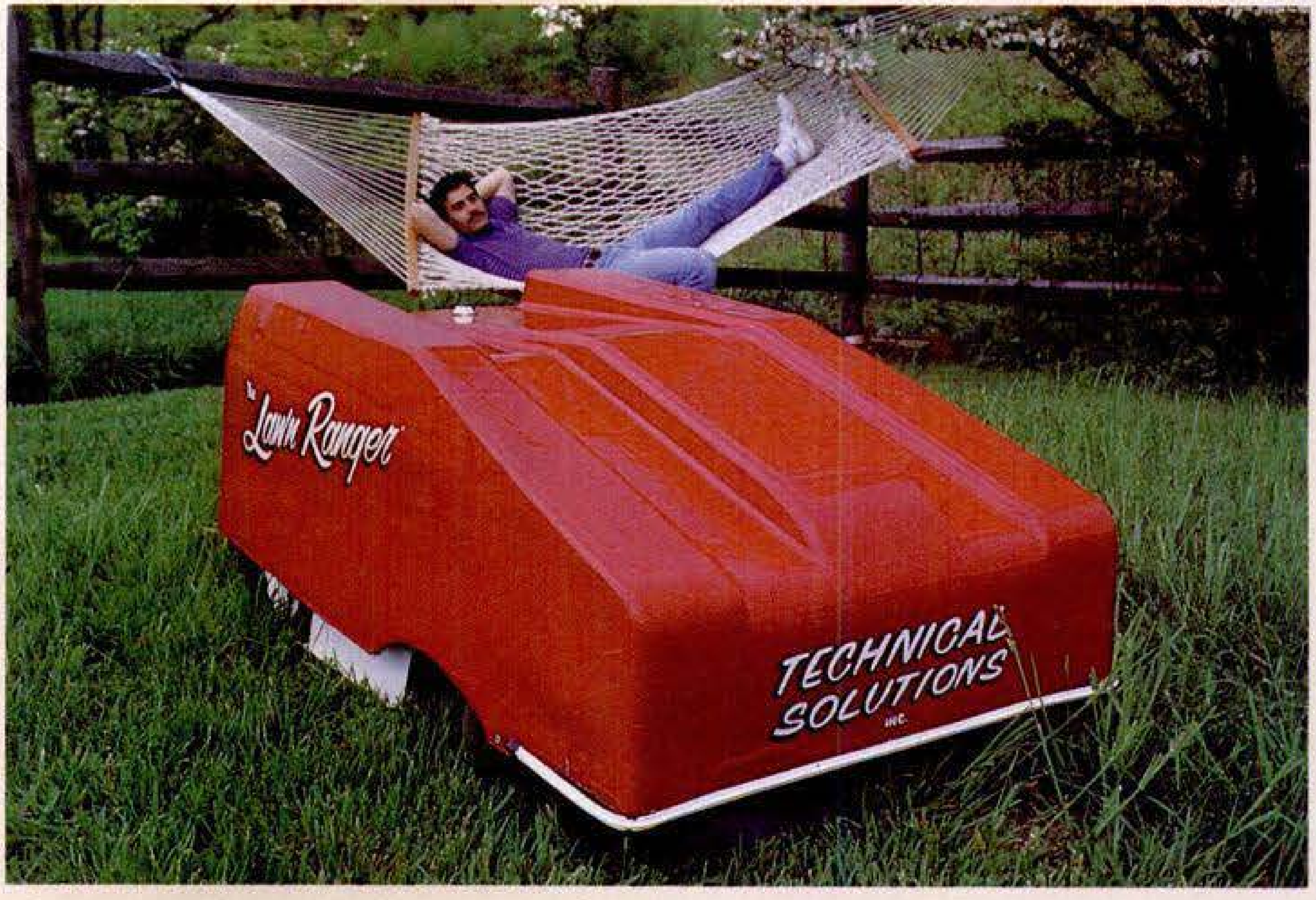
Energy-efficient lighting, naturally

Twenty percent of the electricity generated in the United States goes for lighting, says the Department of Energy. Switching from incandescent to fluorescent bulbs can reduce that number. So can occupancy sensors that turn the lights off when a room is empty. Perhaps the most alluring approach is to use natural light more effectively.

One promising daylighting system, called a variable-area light-reflecting assembly (VALRA), is shown on the next page. It was invented by T. C. Howard of Synergetics, Inc., an en-

HI HO, HAMMOCK!

RANDALL BURDETT



...It's the Lawn Ranger, a bright-red robot that slithers around the yard, cutting a 25-inch swath of grass with each pass. Once you've got it started, you can enjoy the spectacle from your hammock (or from your incredulous neighbor's deck).

The mower, invented by Ray Rafaels, gets its sense of direction from a patented electronic guidance system that includes 15 infrared sensors. The sensors can distinguish the demarcation line between cut and uncut grass as long as the height difference is at least one-half inch. An optional sonar obstacle detector provides input signals to steer the mower around trees and shrubs.

To start the robot on its rounds, you attach a joy stick by wire then guide it around your lawn's perimeter, cutting the first swath. If your Lawn Ranger is not equipped with sonar, you also must mow a path around all obstacles. That done, you unhitch the joy stick and switch the robot mower to automatic. It follows the path, around and around, until it reaches the center of the lawn. There it pivots twice to check for uncut grass. Finding none, it turns itself off.

The little robot uses two 24-volt rechargeable batteries to power four electric motors: two for propulsion and two to spin the dual cutting blades. All turn off within three seconds if the mower's bumper hits something.

Vital statistics? Operating speed: 120 to 180 feet per minute; size: 15 by 28 by 44 inches; weight: 150 pounds; running time on a battery charge: two to four hours; recharging time: three hours with the quick charger, 10 with the normal charger. Technical Solutions, Inc. (Box 284, Damascus, Md. 20872), sells the critical parts as a kit: electronic circuits and sensors—plus mechanical drawings and a videotape to tell you what to do next. Cost: $777.—*V. E. G.*

THE FASTEST WAY TO A FINE FINISH

If you'd like to shorten the time it takes to get a perfect finish on your next project, try one of Porter-Cable's new Random Orbit Sanders. They're built to give you perfect, swirl-free sanding every time. And they accept Stikit® discs, in all paper weights, including micron paper for solid surface work. The result? Faster sanding, smoother sanding than ever before. Superb handling is assured by an ergonomically designed front hand-grip and motor housing.

Choose our five-inch, 6,000 OPM sander (Model 7334), or one of our variable speed units (Model 7335 for a five-inch disc), or (Model 7336 for a six-inch disc). So make short work of your next finishing job with one of Porter-Cable's new Random Orbit Sanders. They're available now at Porter-Cable Professional Tool distributors everywhere. Or call us at 1-800-264-0134 for the location of the distributor nearest you.

PORTER+CABLE
PROFESSIONAL POWER TOOLS
A Pentair Company

SLUDGE
HAMMER

CLEANS INJECTION SYSTEMS, FUEL LINES AND CARBURETORS!
THE KICKGAS GUARANTEE
104% REFUND. ONLY FROM 104+!
See guarantee on back
104 OCTANE BOOST
FUEL SYSTEM CLEANER
NET 8 OZS. .236 LITERS
HARMFUL OR FATAL IF SWALLOWED
DANGER: Contains petroleum distillates. Read other cautions on back carefully.

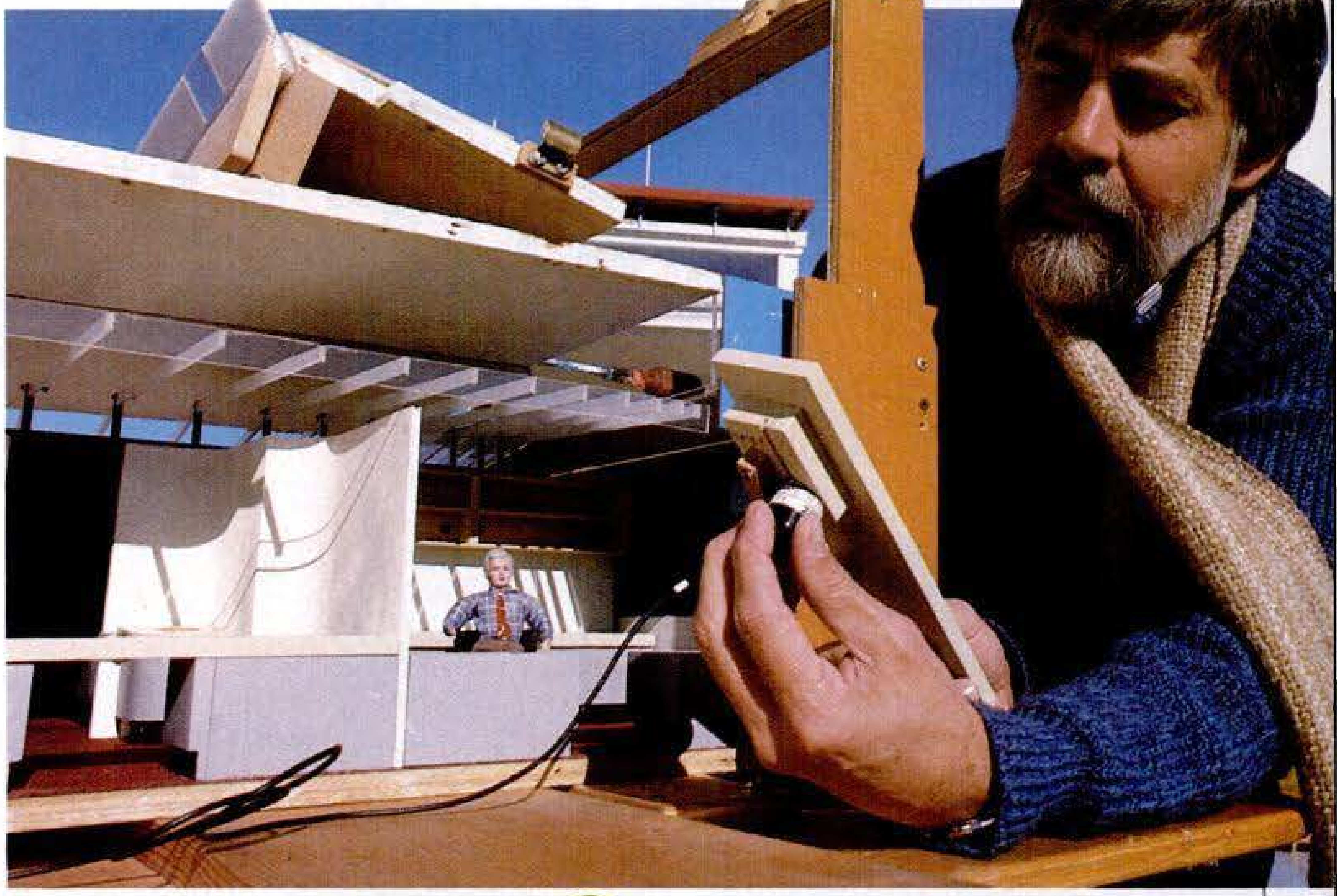
Cleaning and protecting your fuel system is easy as opening a bottle of 104+ Fuel System Cleaner. Just one powerful bottle destroys power-grabbing sludge, gum and varnish. Pour some in and get the power, performance and protection you need.

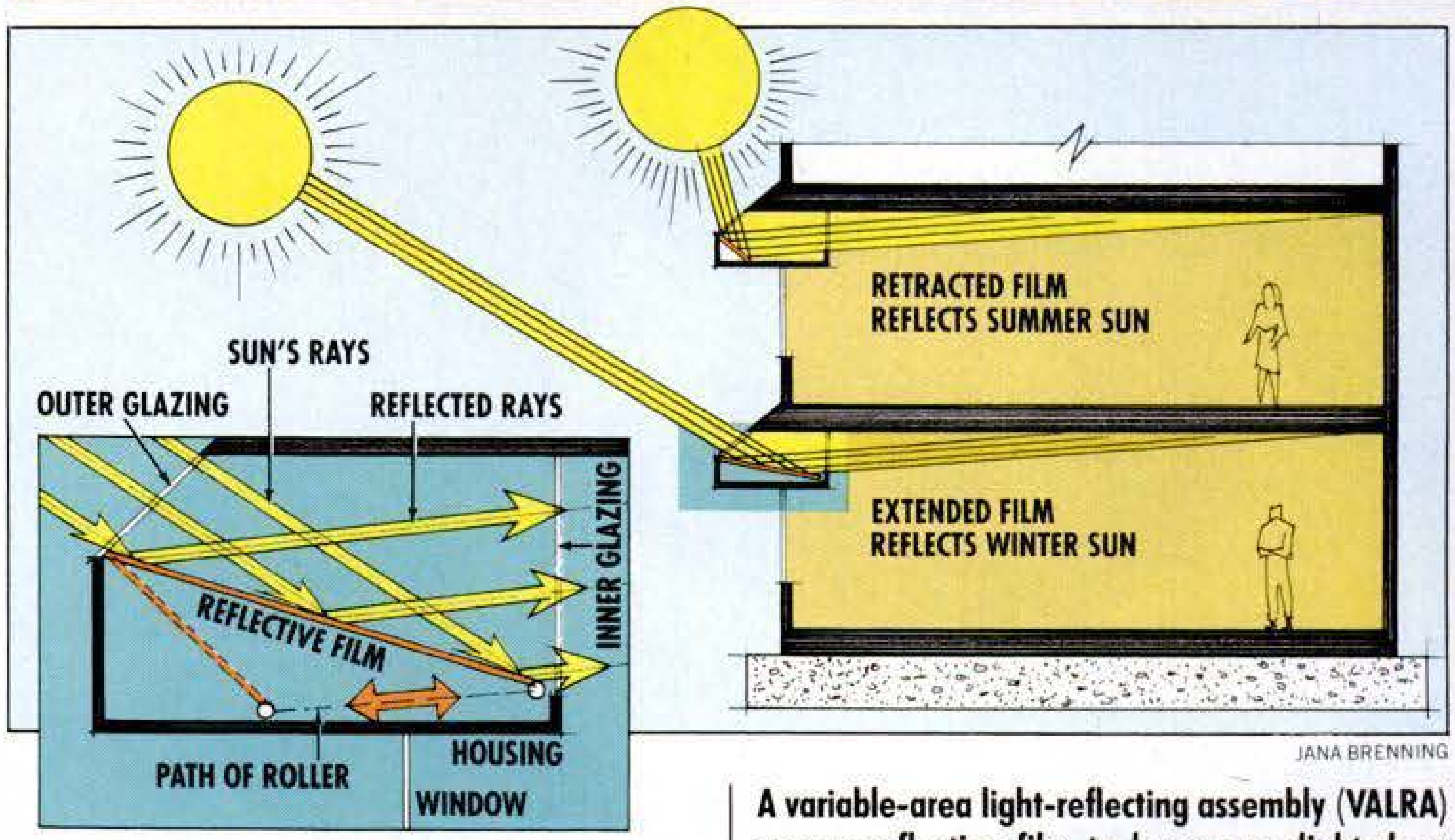
FOR THE DEALER NEAREST YOU CALL 1-800-PAR-3336.

Order Octane Boost products direct: Racing Decal. Full color logo sticks on any clean, smooth surface. 7″ × 3″. Four for $1.05.

104 OCTANE BOOST

FOR THE LONG RUN.
OCTANE BOOST CORPORATION
Box 271148 Dallas, Texas 75227





JANA BRENNING

A variable-area light-reflecting assembly (VALRA) uses a reflective film to bounce sunlight deep into a room (drawings). The film's position changes to match the sun's angle. Dr. Wayne Place of North Carolina State University (photo) installs light sensors in a model room to test VALRA's effectiveness.

gineering and architectural company founded by Buckminster Fuller.

With the VALRA design, sunlight streaming into a special aperture strikes a silver-coated Mylar film, which reflects it, sending it through an inner glazing and deep into the room. The film's inner edge is attached to a roller. As the sun moves, daily and seasonally, the film's angle changes. Motor-driven computerized controls automate the film's movement.

Dr. Wayne Place, a well-known daylight researcher at North Carolina State University in Raleigh, has tested the VALRA and other daylighting systems extensively. Place and his colleagues first build model buildings, put light sensors in them, then attach them to a heliodon, a turntable they can steer to position the model at any angle relative to the sun. If a design proves effective, they then build a full-scale mockup and place it in a full-size rotating test building.

Such tests have shown that a VALRA can direct sunlight up to 100 feet into a building at solar noon on a day with full sun. But because solar conditions vary, a more practical goal would be to count on daylight penetration to a depth of 40 feet, Place says. Model studies and computer simulations show that a VALRA system could reduce electricity used for lighting by 71 percent in Phoenix and 44 percent in New York City. In fact, the dollars saved would be greater in New York because of its higher kilowatt-hour rate.

Sunlight is intermittent, though, so a backup conventional lighting system must be installed. That's a big expense.

It's also a big problem. In commercial buildings, which is where daylighting offers the best cost savings, the backup lighting would be fluorescent. Dimmers would take their cues from photo sensors that would constantly measure the incoming sunlight.

The problem? Fluorescent dimmers take about 10 seconds to respond to changing light levels. Imagine finding your desk in momentary darkness every time a cloud obscured the sun. "It would drive people nuts," Place says. "So we have this daylighting device that works just fine; it's the electric lighting side of the equation that is not working." He hopes to develop a quick-response fluorescent dimmer himself, or persuade the industry to do it.

A cool way to fight global warming

"You don't have to send money to a rain forest-protection fund to do your bit to fight global warming," says Ruth Parnall of Conway Design Associates, landscape architects in Conway, Mass. "You can help right here at home."

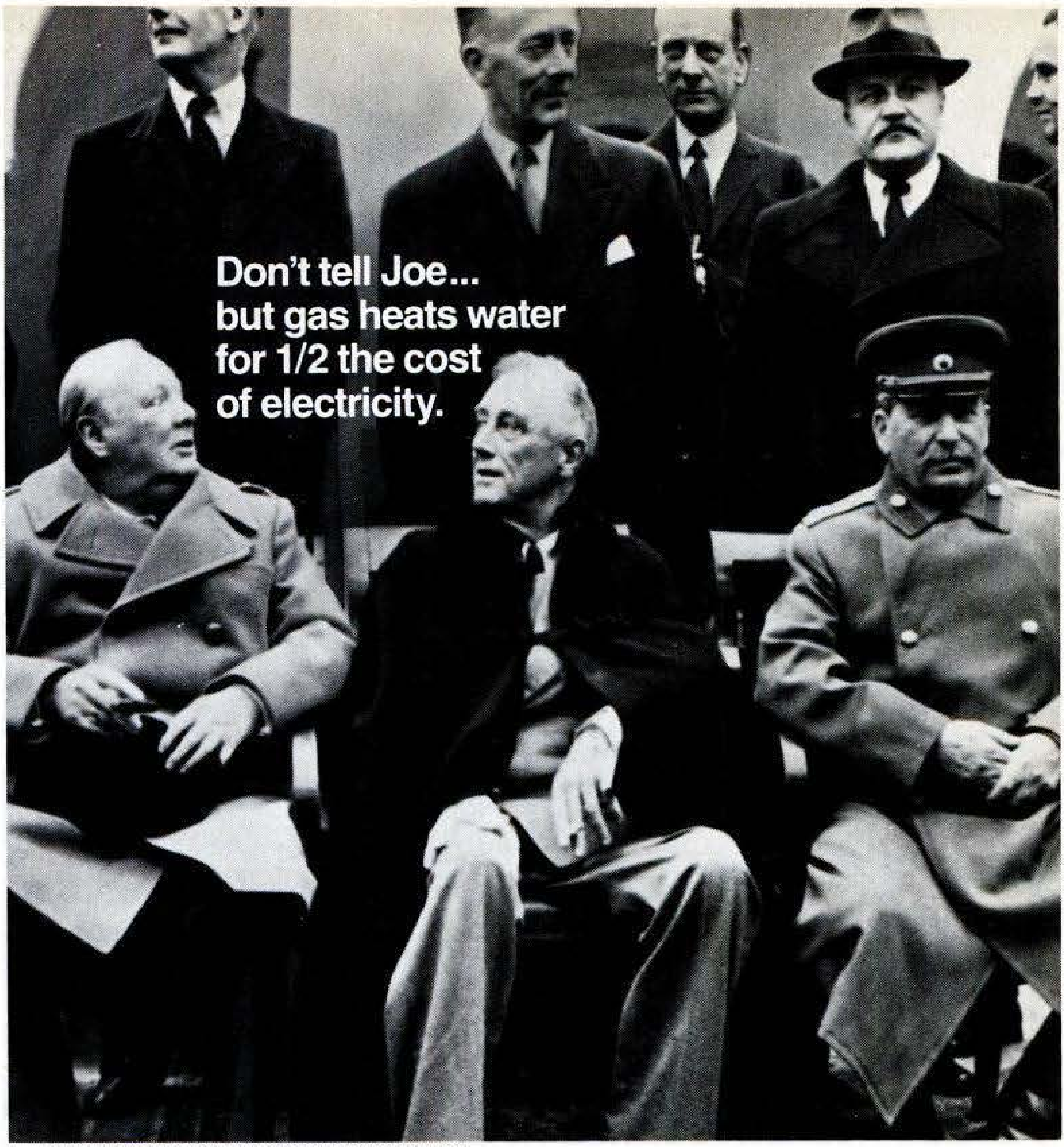
How? By protecting existing trees during any construction project, and by planting new trees, she says. In the process, you can save money.

Trees work against global warming in two ways. First, they absorb carbon dioxide, a greenhouse gas, during their lifetimes (more, in fact, than they give up when they die or are burned). Second, trees can shade your house and grounds, reducing your air conditioner's cooling load. This cuts the amount of electricity you have to buy. And that electricity may have been produced in a carbon dioxide-belching fossil-fuel power plant.

"Trees are probably the most important factor in passive cooling," asserted Parnall, who spoke at the Northeast Solar Energy Association's recent conference on advanced residential construction. "Keep them healthy and you'll save a bundle on air conditioning."

Research supports Parnall's contention. In a five-year study in Gainesville, Fla., University of Florida professor Rick Larson found that tree-shaded homes used 50 to 80 percent less energy for air conditioning. "I feel strongly that these findings could be extrapolated to any climate," says Larson. "While the cooling season is longer here than in, say, Chicago, the heat there is just as intense.

For information on energy-conserving landscaping, write to Parnall at Box 264, Conway, Mass. 01341 (include a self-addressed stamped envelope).


Don't tell Joe...
but gas heats water
for 1/2 the cost
of electricity.

CULVER PICTURES © 1990 AMERICAN GAS ASSOCIATION

A Great Opportunity
to take advantage of the Hottest Idea in Home Building!

Join the industry leader. Become a Distributor of our innovative steel framed homes.

DISTRIBUTORS WANTED IN SELECT AREAS

Tri·Steel makes it easy to get started with:
- Low refundable investment programs
- Unrestricted territories
- No franchise fees
- Substantial discounts
- No inventory required
- Advertising support
- Construction assistance
- Hands-on construction training
- Training & support materials
- Hundreds of floor plans

The advantages of Tri·Steel Homes include:
- Super energy efficient (R-30) insulation
- Fire & termite resistance
- Fast, simple construction
- 100+ m.p.h. wind resistance
- Seismic 4 earthquake rating
- Clearspan interior flexibility
- High strength
- Low maintenance
- Affordability
- Custom design service
- Over 80 standard models

Call Paul Samuels today for a video tape or a FREE Information Packet:

Tri-Steel Structures Call toll free: 1·800·TRI·STEEL
or (214)580-1200 Fax: (214)550-0353

THE KNOW-IT-ALL RADIO

This Realistic® Scanner Puts You in The Know—Hear News As it Happens

Listen in on police and fire calls, trains, planes, Hams, weather—you name it. Realistic PRO-2022 stores up to 200 channels and it's programmable so you don't have to buy crystals. It couldn't be easier to use. Just enter frequencies on the keyboard to tune all the popular "action" bands, including VHF-air and 800 MHz. You get handy features like priority channel, scan delay to prevent missed replies, and a search mode to discover unpublished channels automatically. A detachable antenna is included.

The PRO-2022 delivers outstanding audio clarity and it's backed by a one-year limited warranty. A low-cost five-year Tandy Service Plan is available. Exclusively at participating Radio Shack stores and dealers for $349.95. Try out the know-it-all radio soon.

CREATING NEW STANDARDS

PROVEN LEADERSHIP. Over 7000 USA locations, 39,000 employees, seven R&D centers, 31 USA and overseas manufacturing plants—*NOBODY COMPARES*

GUARANTEED SATISFACTION. Over 35 million customers benefit from our Satisfaction Guarantee. Putting you first made us #1 in electronics—*NOBODY COMPARES*

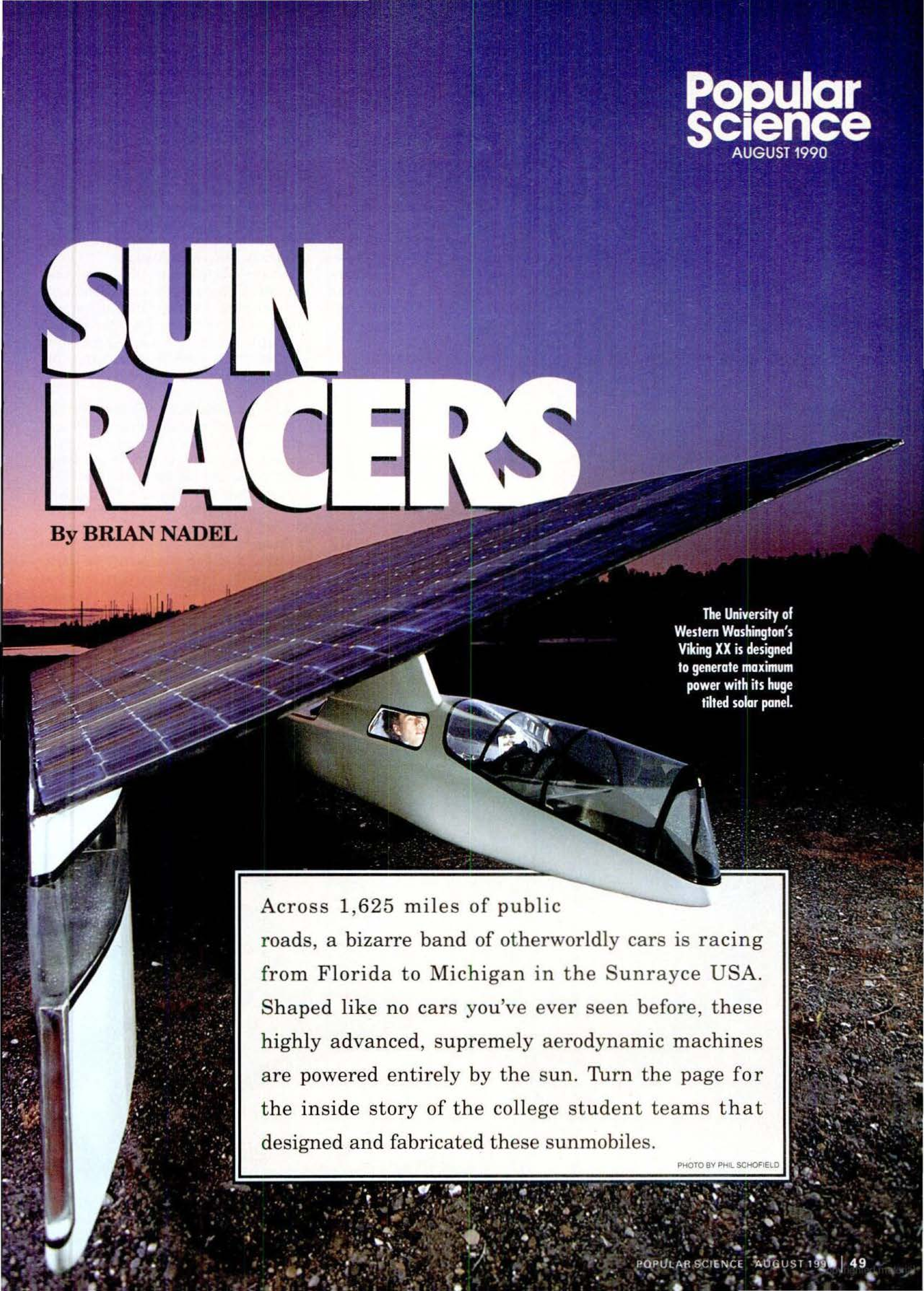
Radio Shack®
AMERICA'S
TECHNOLOGY
STORE℠

Radio Shack is a division of Tandy Corporation

Popular Science
AUGUST 1990

SUN RACERS

By BRIAN NADEL



The University of Western Washington's Viking XX is designed to generate maximum power with its huge tilted solar panel.

Across 1,625 miles of public roads, a bizarre band of otherworldly cars is racing from Florida to Michigan in the Sunrayce USA. Shaped like no cars you've ever seen before, these highly advanced, supremely aerodynamic machines are powered entirely by the sun. Turn the page for the inside story of the college student teams that designed and fabricated these sunmobiles.

PHOTO BY PHIL SCHOFIELD

Most of the year, the highways stretching between America's snowbelt and subtropical Florida are filled with winter-weary vacationers anxious to recharge their spirits in the sun. This month, though, those roads will host sun seekers of another variety—featherweight, ultra-sleek race cars prepared by college teams from the United States and Canada and powered exclusively by solar energy. Traveling northbound 1,625 miles to the Motor City, they will be competing for top honors in the 11-day General Motors-sponsored Sunrayce USA (see box).

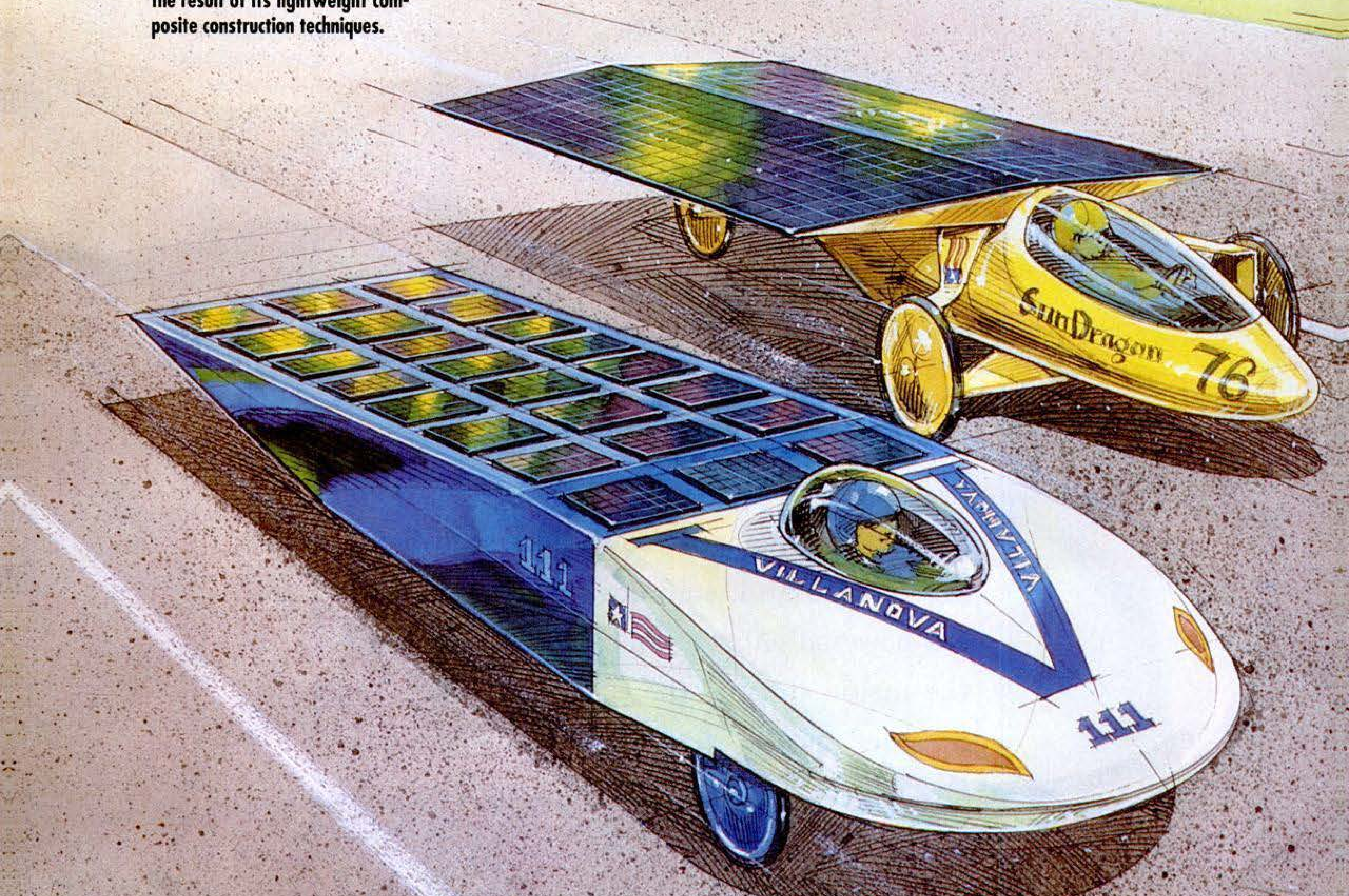
Dave Mitchell, race liaison from the Society of Automotive Engineers, considers the event a stimulant for the technical development of electric cars. "This type of exercise pushes the technology and increases the awareness of the solar alternative."

As in other forms of motor competition, the performance limits of the Sunrayce entrants are well-defined. In this case, the total amount of solar energy that can be collected restricts each car's output. Reducing the energy lost during the race is critical. As Don Runkle, GM vice president, advanced engineering staff, puts it: "This type of race teaches us how important losses and inefficiencies are, and that they must be reduced to a minimum. Hopefully we'll see new approaches to friction reduction, solar-cell efficiency, and aerodynamics."

Art Boyt, the faculty adviser for the Crowder College team, says, "Think of it as driving a car at fifty miles per hour on the power of a hair dryer—roughly 1,500 watts—and you immediately see the importance of reducing aerodynamic drag to a minimum."

Michael Seal, faculty adviser for the Western Washington University's solar car effort agrees: "There are two priorities in this race: Generate the maximum power and use the minimum." He figures that the school's Viking XX (pictured on the previous page and the front cover) will be a frontrunner because it takes advantage of a rule allowing a larger solar array for cars carrying two people. The car's radical

Four unique solar car designs (counterclockwise from below): The successful General Motors Sunraycer was used as a starting point in sculpting Villanova University's Wild Solarcat and Iowa State's Prisum; Crowder College's Star II uses aircraft aerodynamics to lower the drag coefficient of its two-person solar car; the organic shape of Drexel University's SunDragon is the result of its lightweight composite construction techniques.



profile is defined by a large tilted solar collector that can generate up to two kilowatts and rides on a pair of wheeled pods. One pod houses the driver, passenger, and drive wheel, while the other pod carries the battery pack and a pair of steerable wheels.

The fixed slope of the solar cell surface provides effective energy gathering while the sun is aimed at it, but loses out when the sun crosses to its opposite side in the afternoon. The solution: A steering wheel at each end of the passenger pod allows the car to travel in either direction. When the shadows start to fall on the solar cells, the car simply turns to realign the array with the sun.

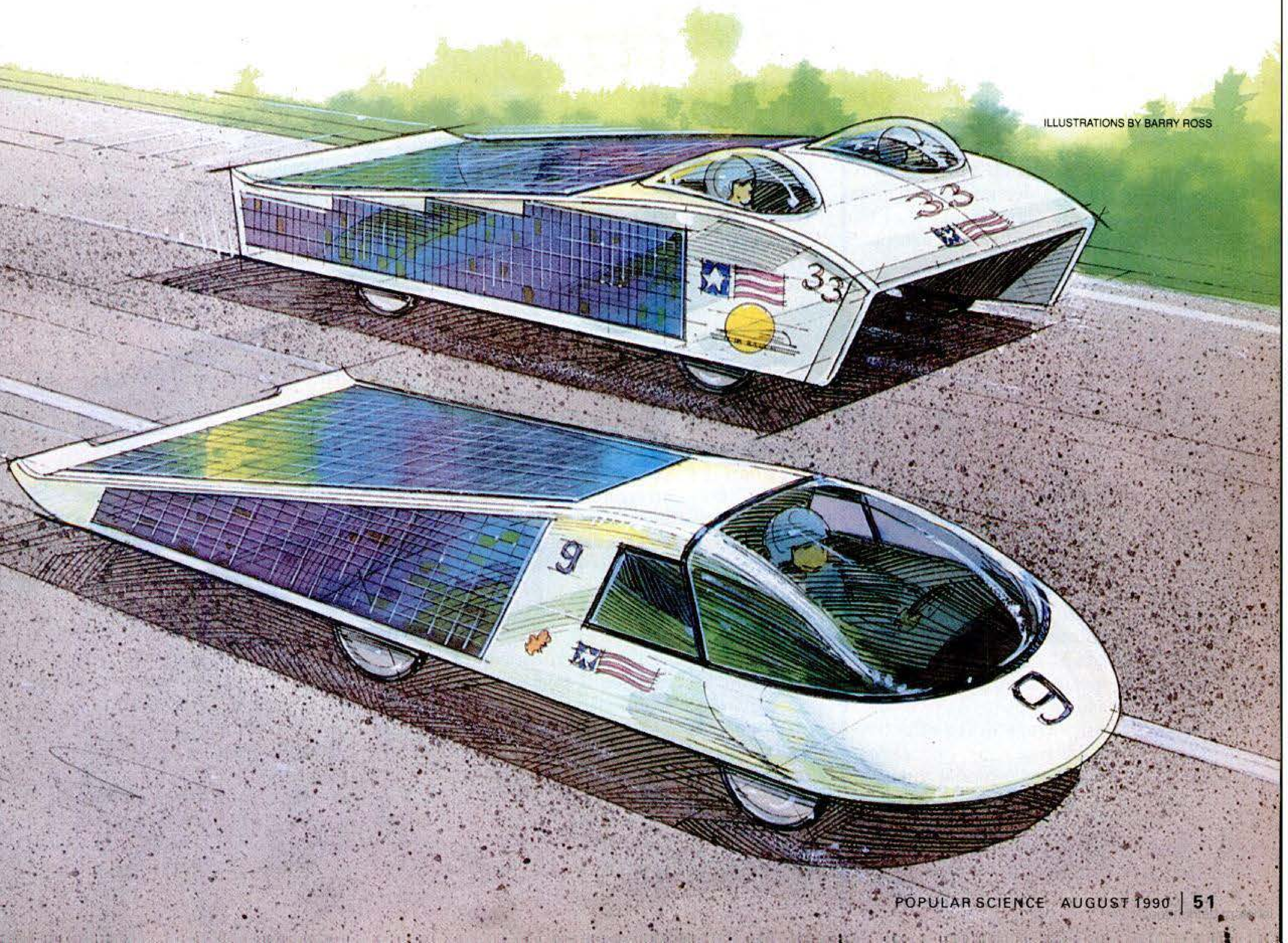
This clever design is not without its drawbacks. The enormous surface area of the tilted array can act like a huge sail in a crosswind, literally pushing the Viking XX off the road. To counteract a steady wind, the team's engineers have devised a yaw-control pedal that allows the driver to adjust the orientation of the vehicle with respect to the wheels, letting the car skirt the wind. Even with that fix the car is a handful in a stiff breeze. Noted one observer: "That car is as boxy as a house and handles like one too."

Still, the message behind all this effort is clear. Each team is trying to create a winning advantage based on innovative design solutions to the unique challenges of solar car racing. In truth, just about the only common feature is the path of electric power flow. All the cars run on a trickle of electricity that is generated by photovoltaic solar cells and stored in batteries to power an electric motor. Beyond that basic formula, each team will go its own way while staying within the rules (see box).

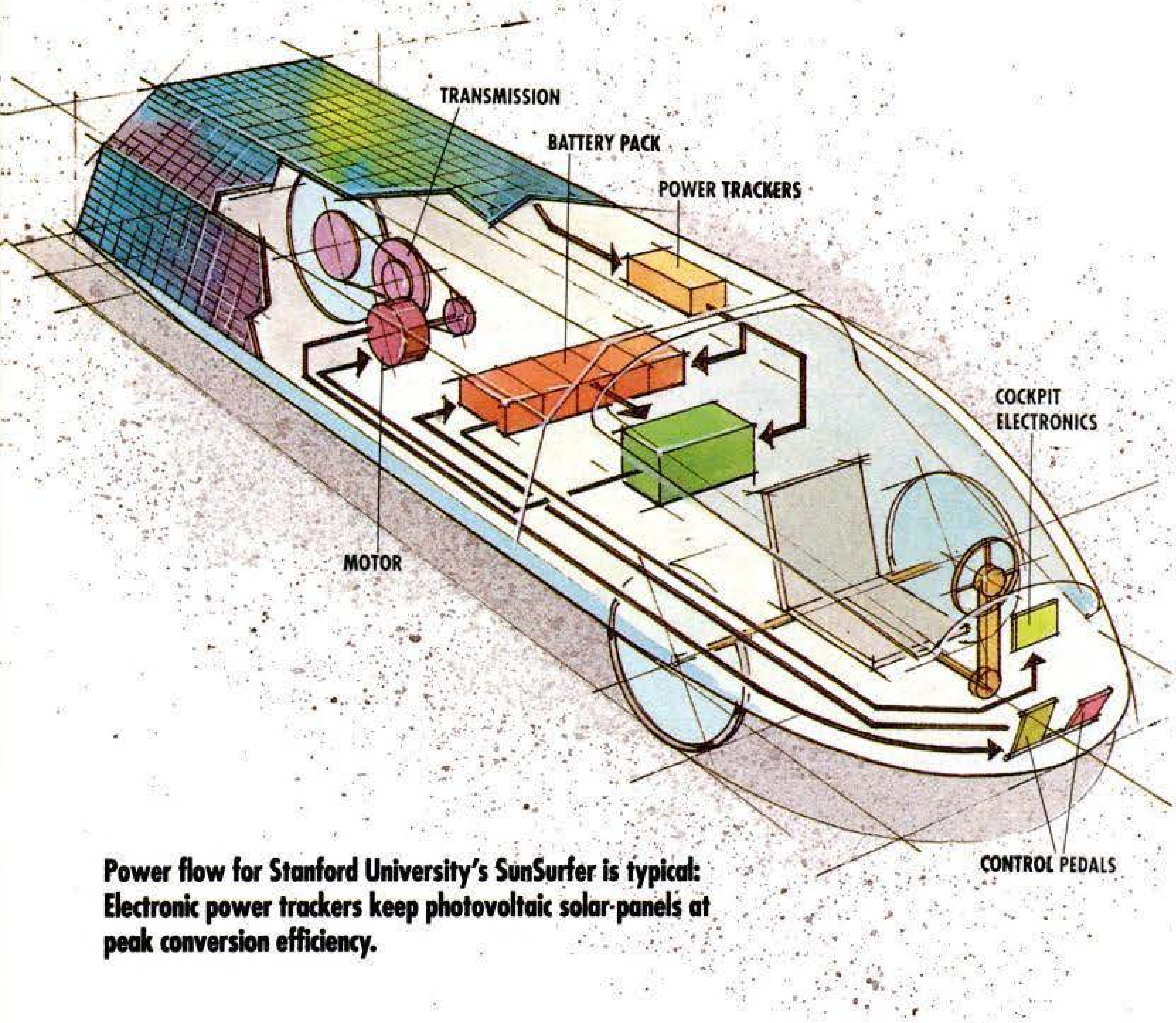
Some teams have chosen to play it safe, closely modeling their cars on the profile of the GM Sunraycer, winner of the Pentax World Solar Challenge across Australia in November 1987 [Nov. '87, Feb. '88]. The advantage is apparent: A model of the Sunraycer achieved a 0.089-coefficient-of-drag rating. (The competition Sunraycer had a Cd closer to 0.12.) As University of Maryland's Rob Piacesi says, "Nothing works like sticking with a winner. We used the GM Sunraycer as a goal to beat." The Pride of Maryland solar car mimics the sleek Sunraycer in many ways, from its long, gently sloping tail to its smoothly rounded front end and driver canopy. The Maryland team's car has a higher coefficient-of-drag rating of 0.13, but total aerodynamic drag is lower because the frontal area is 27 percent lower than the Sunraycer.

Initially, tests in the wind tunnel at the College Park, Md., campus indicated that a swift side wind could pick the car off the ground, resulting in a race-ending rollover. The changes included replacing the flat panel of solar cells with a peaked arrangement that makes the car look like a cross between an armadillo and a pup tent on wheels. The crosswind will cleanly break away from the body at the array's peak, or at least that's the idea. "It's not a conventional aerodynamic theory. It was developed in our wind tunnel," says Piacesi.

Villanova University's Wild Solarcat is a similar design, but uses a flat solar array along its back surface. The Iowa State effort goes a step further by using trapezoidal-shaped panels that fit together to form a squared-off rear of the car.



ILLUSTRATIONS BY BARRY ROSS



Power flow for Stanford University's SunSurfer is typical: Electronic power trackers keep photovoltaic solar-panels at peak conversion efficiency.

The Crowder College team took a longer perspective on sculpting the body's shape. Boyt recalls that the genesis of the car's configuration began with a 1948 Popular Science article on early theories on the design of airplanes that would break the sound barrier. These ideas became the basis of the inverted "U" shape of Crowder's Star II solar racer. The decision to use this design wasn't made without serious consideration of the car's stability. Boyt's fears are more than idle worry—Crowder's entry in the 1987 trans-Australia race flipped over in a 30-mph crosswind, eliminating the team's chance of a second-place finish.

Boyt explains the key advantage they're trying to exploit with the tunnel design: "If you can avoid either compressing or expanding air traveling through a confined area, turbulence and aerodynamic drag will be reduced." In practice, this theory quickly fell into disfavor because of the erratic handling of the planes built with it. Nonetheless, the concept still has merit, and the Star II has a carefully sculpted underbelly to maintain a constant cross-sectional area and to keep air flowing through at a steady pressure.

"The results were quite effective," says Boyt. "We ran wind tunnel tests on a one-fourth scale model alongside a standard textbook airfoil design. The result is that our design gave twenty percent less drag without the canopies and ten percent less drag with canopies. The pair of canopies are a source of turbulence, but we just couldn't avoid it. After all, the driver's got to see the road ahead."

To be competitive, the teams will have to make the most of the sunlight that strikes the up-to-13.7-foot-long solar array allowed under the rules. (Vehicles that carry a driver and a passenger are allowed a 19.7-foot-long solar array.) The typical car's solar panel is made of four-inch-wide discs of silicon that are only a few thousandths of an inch thick. Power conversion efficiency increases with price. For example, the terrestrial grade of single crystal silicon solar cells is at best 15 percent efficient at converting sunlight to electricity. The price of the typical solar panel for the race is $15,000 and produces between 1,000 and 1,500 watts of power. Teams can squeeze out another five percent efficiency by upgrading to high-purity space-grade silicon or gallium arsenide cells originally designed for satellites, but at a tenfold price increase.

Prof. Richard Swanson of Stanford University's electrical engineering department has devised a few tricks to coax even more electricity out of the silicon cells for the SunSurfer. To start with, the cells are made from top quality single-crystal silicon wafers, the type usually reserved for complex electronic chips. For further efficiency, the cells are wired on the bottom, leaving more space open to the sun to generate electricity. These developments enable the Swanson cells to achieve a 23 percent conversion efficiency.

"The problem is the lack of time prior to the race," according to Stanford student coordinator Stefan Heck. "At best we can cover only about half of the body with the Swanson cells; the rest will be standard cells. The overall efficiency of the combined arrays will be around twenty percent." Heck estimates the cost of the Swanson cells at $100 apiece, compared with $4.50 for standard cells. Stanford's budget for solar cells is more than $81,000.

"No doubt about it, the cost of entry to the solar car club is very steep," muses Mitchell of the SAE. "But, it isn't clear that a team will be able to buy the race with a large budget. It will take a dependable car to cross the finish line first."

Besides solar input, the only other way to charge the batteries under the rules is to tap momentum built up on the road when it comes time to slow down. This is called regenerative braking and involves setting the motor's power controller for a slower speed than the car is traveling, which forces the motor to act like a generator. Practically, it means that the brake pedal will activate the regenerative system on the first inch or so of travel, and only when pressed further will the brakes take over.

In the interests of simplicity and weight reduction, Rose-Hulman Institute of Technology's Solar Phantom will not use a regenerative system. Engineering student Kynan Church maps out the team's strategy: utilize the solar array as the only input to the system. His biggest fear: "Coasting down a hill with a stop sign at the bottom. We'll have to pull away very slowly to preserve battery charge.

"As far as batteries go, the silver-zinc units we'll be using are state of the art," says Church. Originally designed for use in satellites, they are the lightest, most powerful batteries available today. All of the solar car teams interviewed for this article will use the silver-zinc battery.

Ideally, a solar car's shape is something more than a theoretical exercise in weight-conscious construction. The Drexel University SunDragon uses composite materials to save weight without sacrificing aerodynamic design. The university's eight-foot diameter braiding loom wrapped a Styrofoam pattern of the car with carbon fiber threads. Then it was treated with an epoxy resin and cured. Dr. Frank Ko, director of Drexel's Fibrous Materials Research Center, says the car with driver in place weighs less than 500 pounds and contains only a handful of metal parts. Ko calls the pointed nose design an organic shape that is based on the profile of a helicopter.

Rose-Hulman Institute students used a simpler version of this scenario, wrapping a mold with sheets of composite material, then treating and heat-curing the structure. To make the monocoque structure even stronger, they have taken a cue from the cars that race at nearby Indianapolis Motor Speedway, basing the chassis on a lightweight aluminum honeycomb sandwiched by sheets of carbon-fiber fabric. According to engineering student Church, "The car with driver should weigh only 450 pounds." That compares favorably with larger entries, like the 750-pound Viking XX.

The Pride of Maryland takes an approach that exploits the unique qualities of two composite materials. The car's skin is a sandwich of two sheets of lightweight Kevlar aramid fiber on the outside with a honeycomb of sturdy Nomex nylon at the center. A sample that Piacesi showed me looked like a corrugated cardboard box ripped open, but the ¼-inch-thick material is as stiff as aluminum, at a fraction of the weight. The skin will be bonded with adhesive to a tube aluminum frame. The car and driver will weigh about 550 pounds.

With the final chassis taking shape on a lab table at the University of Maryland, I asked Piacesi about its history. Striking a raw nerve, I found out the design was the result of many hours spent hunched over a computer design terminal, and even more time trying out ideas with models. "An early prototype looked perfect: light and strong," says Piacesi as he points to a one-eighth-scale wire model that hangs on the wall. "The only problem was that the driver couldn't get in."

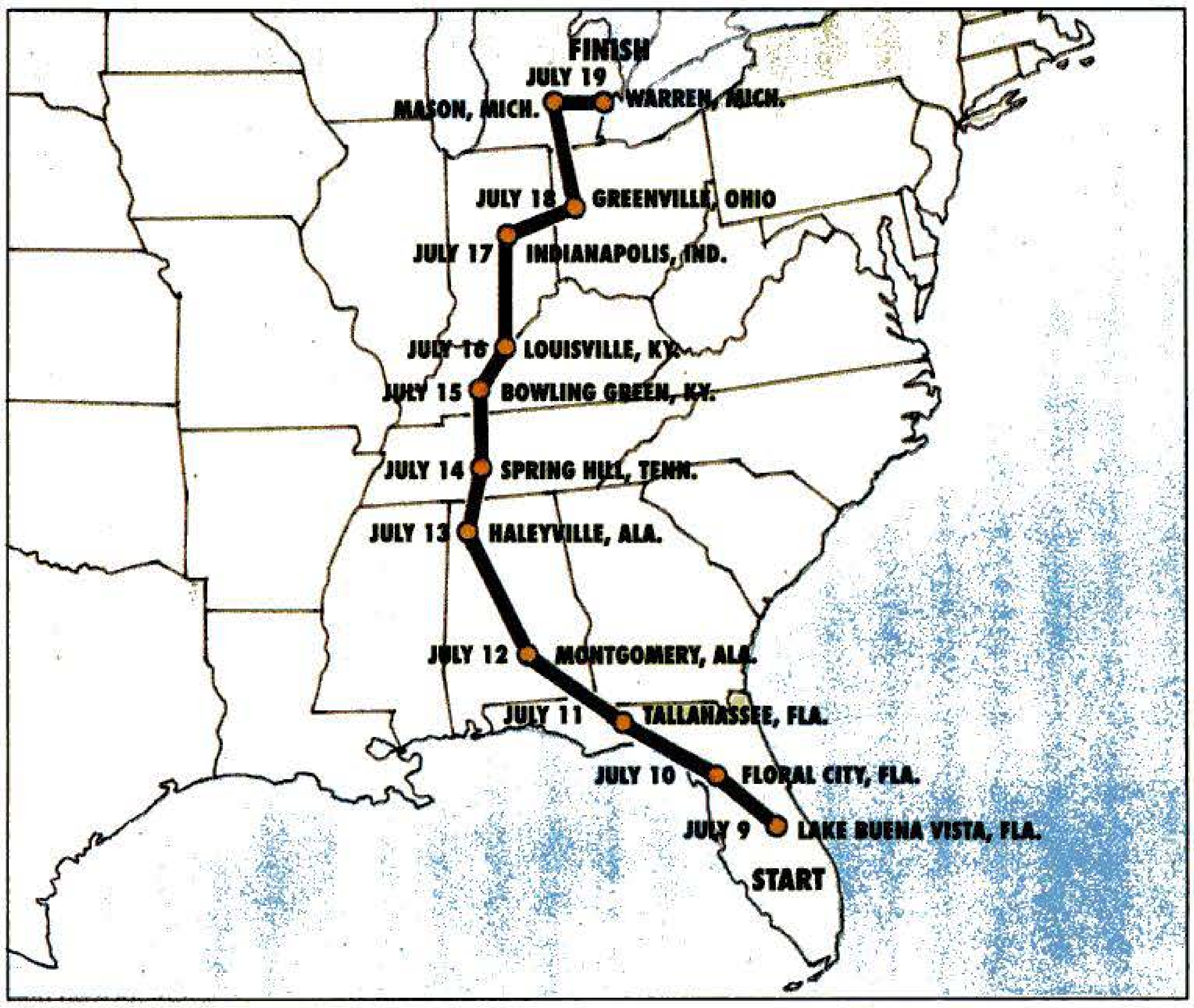
On their eleventh try, the Maryland team hit on what they considered the optimal frame. But to fit below the canopy, the driver will have to sit almost fully reclined. "Not only will this require a shorter than average driver, but also one who isn't claustrophobic," notes Piacesi.

Because this race takes place on everyday roads, not on a carefully groomed track, hazards like potholes, railroad crossings, and frost heaves are a constant threat to the fragile cars. For that reason, the front suspension components of the Maryland car are like those of many passenger cars: a pair of control arms to maintain control when driving over bumps.

Drexel's alternative is a winglike all-composite suspension for its SunDragon. The front control arms look like dolphin flippers, flowing naturally from the car's pointed nose to meet in a vertical section that holds an aluminum spindle. Michael Quadrini, a Drexel mechanical engineering student, explains that the SunDragon's suspension uses no metal springs, relying instead on the flexing ability of the arms, much like the fiberglass leaf springs on Chevrolet's Corvette. The top arm provides lateral support and the bottom deflects with a spring rate of 100 pounds per inch of travel. Quadrini notes that the composite design cuts suspension weight by more than half.

[Continued on page 88]

THE RULES, THE ROUTE



All entries in the 1,625-mile Sunrayce USA are subject to a technical and safety inspection before qualifying for a starting position.

•All entries must fit into a box 19.7 feet long, 6.6 feet wide, and 5.2 feet tall.

•The solar array must not exceed 13.1 feet of that length for a single-seat entry; the array for a two-seat car can cover the entire body.

•For two hours at the end of each day and two hours before the teams hit the road the next morning, the teams can charge their car batteries in the sun. No overnight maintenance of any kind is permitted.

•Racing will occur from 9 a.m. to 6:30 p.m., with a mandatory pit stop at 11 a.m. Cars that do not complete the day's route must be transported to the overnight impound area and will be assessed a time penalty.

•The cockpit must be fully enclosed on the bottom, seats must have five-point safety harnesses, and in an emergency an occupant must be able to escape in 15 seconds.

Other than that, it's a race to see which car can travel the 1,625 miles from Florida to Michigan in the shortest time, fueled exclusively by the sun. The car with the lowest actual elapsed time on the course wins.—*B. N.*

THE COLLEGE TEAMS: As of press time, there were 32 student teams entered in the race: **Sun Devil Cruiser** Arizona State Univ. (Tempe); **Sol of Auburn** Auburn Univ. (Auburn, Ala.); **Solar Flair** Calif. State Polytechnic Univ. (Pomona); **Sun Luis** Calif. Polytechnic State Univ. (San Luis Obispo); **Solar Eagle** Calif. State Univ. (Los Angeles); **Csun Blazer** Calif. State Univ. (Northridge); **Kalahkwaneha** Clarkson Univ. (Potsdam, N.Y.); **Stelar V** Colorado State Univ. (Fort Collins); **Star II** Crowder College (Neosho, Mo.); **Sunvox III** Dartmouth College (Hanover, N.H.); **SunDragon** Drexel Univ. (Philadelphia); **Florida Sunshine Special** Florida Institute of Technology (Melbourne); **Prisum** Iowa State Univ. (Ames); **Northern Light** Mankato State Univ. (Mankato, Minn.); **Pride of Maryland** Univ. of Maryland (College Park); **Solectria VII** MIT (Cambridge, Mass.); **Sunrunner** Univ. of Michigan (Ann Arbor); **Centennial** Univ. of North Texas (Denton); **Team Ralos** Univ. of Ottawa (Ontario); **Solsation** Univ. of Pennsylvania (Philadelphia); **The Shining Star** Univ. of Puerto Rico (Mayaguez); **Spirit** Rochester Institute of Technology (Rochester, N.Y); **Solar Phantom** Rose-Hulman Institute of Technology (Terre Haute, Ind.); **SunSurfer** Stanford Univ. (Stanford, Calif.); **Solis Tyrannus Cognoscis** Stark Technical College (Canton, Ohio); **Texas Native Sun** Univ. of Texas (Austin); **Wild Solarcat** Villanova Univ. (Villanova, Pa.); **Solaray** Virginia Polytechnic Institute and State Univ. (Blacksburg); **Midnight Sun** Univ. of Waterloo (Ontario); **Sunseeker** Western Michigan Univ./Jordan College (Kalamazoo/Grand Rapids, Mich); **Viking XX** Western Washington Univ. (Bellingham); **Starduster** Worcester Polytechnic Institute (Worcester, Mass.)

DEEP COVER

Design secrets of our newest ultra-quiet subs.

By T. A. HEPPENHEIMER

Sea wolf: a mythological sea creature that combines stealth and ferocity

That definition is now listed as obscure. But perhaps it's why the U.S. Navy chose Seawolf as the *nom de mer* of its newest class of attack submarines, the SSN-21. To be completed in four years by the Electric Boat division of General Dynamics, the first nuclear-powered Seawolf will be the quietest, fastest, and deepest-diving American sub yet.

Numerous incidents and technology disclosures over the past several years have revealed advances that made Soviet subs quieter and less detectable far sooner than American experts had thought possible. Alarmed defense experts recognize the vital role that submarines and their detection play in U.S. military planning: Our attack subs must locate and destroy enemy ballistic-missile and attack subs early in a conflict—as far away as possible from American shores. They must also protect U.S. ballistic-missile subs and ships carrying troops and equipment overseas.

Such a strategy seemed plausible for decades as the Navy routinely detected clanging Soviet subs—at times *thousands* of miles away. During the 1980s, though, the Soviets experimented with innovative technology aimed at silencing its submarines, making them faster and able to dive deeper. Most U.S. experts had not expected a new generation of stealthy Soviet subs until the mid-1990s.

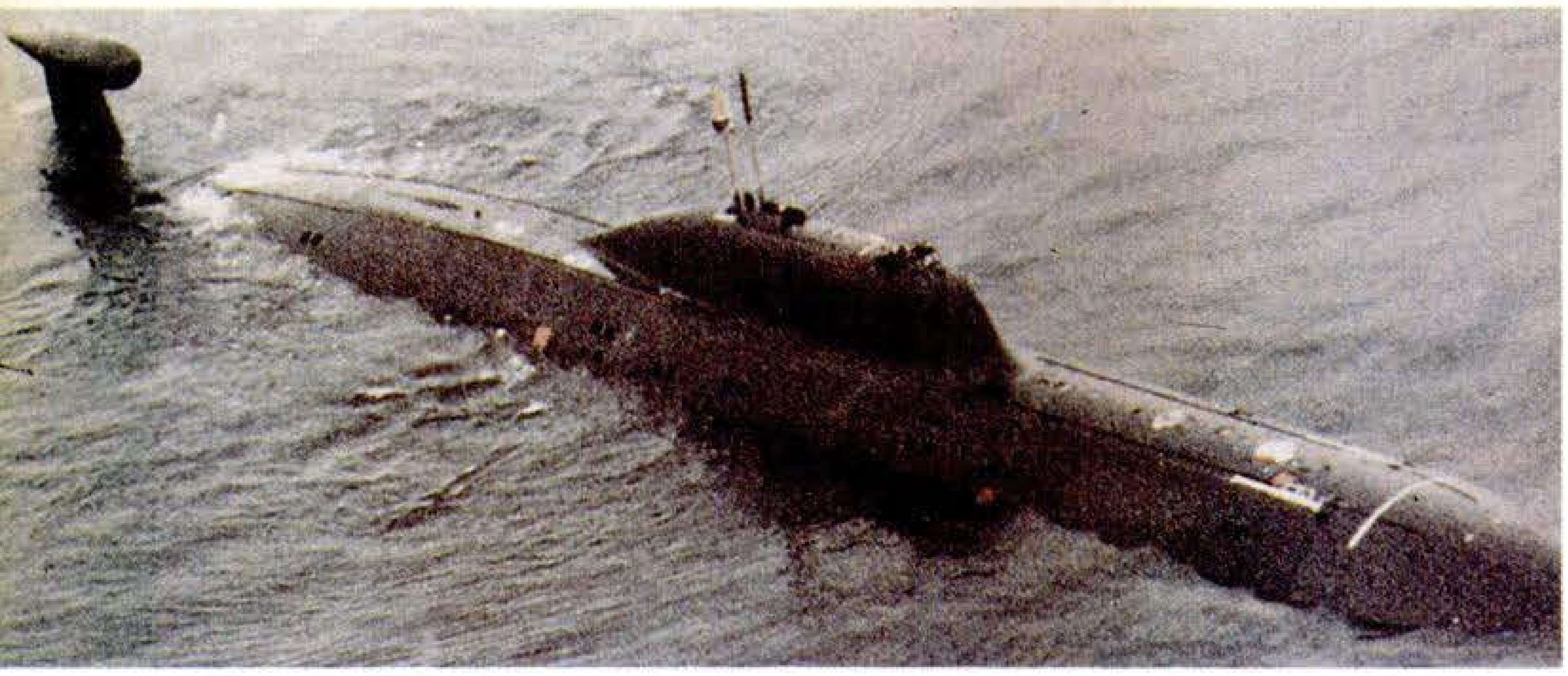
Proponents say the Seawolf's combat system, sensors, and weapons will more than counter Soviet technology. Critics of the controversial Seawolf claim its high cost—more than $1 billion for each submarine—would be better spent updating and buying greater numbers of our current Los Angeles-class attack subs. Because the Seawolf design began in the early 1980s, those alarmed by Soviet developments are urging the Navy to speed technology advances into early models. Despite the squabbling, however, or military spending cuts brought on by political changes in Eastern Europe and the USSR, the $30-billion-plus Seawolf program has survived so far.

Attack subs such as the Seawolf will have a key role in anti-submarine warfare (ASW) strategy well into the 21st century (hence its SSN-21 designation). Surface vessels, aircraft, plus sensors on the sea bed and aboard satellites are also important in ASW ["Invisible Subs," July '85].

Because submarine quieting and ASW is so crucial, the technologies involved are among America's most highly classified secrets. Nevertheless, drawing on congressional testimony and their experience, several naval analysts have written books on sub design and quieting that help lift the veil of secrecy. After talking with these and other experts about submarine quieting, I toured one of our current-generation attack subs.

Submarine-quieting challenges, I discovered, continued when the Navy began switching from diesel-electric submarines to nuclear power in the mid-1950s. Design engineers had to deal with a serious and unexpected problem early in the nuclear submarine program: a reactor's main pumps. As they chug away circulating cooling water to remove heat from the reactor core, they create distinctive hull vibrations. Other noisy pumps

DRAWING BY CARY HENRIE



A Soviet Akula attack sub, thought to be among the fastest, most silent, and deepest diving in service.

circulate water through condensers that convert steam into water. Sensitive hydrophones could detect the noise at great distances. For some subs, the cure is simple.

"Early in the nuclear program," said naval analyst Norman Polmar, "they found that when they turned off the cooling pump, water kept flowing through the reactor." Hot water's natural buoyancy, they discovered, made it rise into the steam-generator portion of the reactor plant without a pump. Designers began using these natural-circulation reactors to help silence large ballistic-missile submarines.

"Such a reactor is built like a chimney," said Ed Kintner, a former head of the Navy's advanced-design group, now executive vice president with GPU Nuclear Corp. In his Parsippany, N.J., office he sketched a diagram on a pad. "It's like a fireplace, where hot gases go up and cold gases come down," he explained, indicating the "chimney" (reactor pressure vessel) must be tall with wide passages for the water to have enough driving force. When high power and speed is necessary, a backup pump is used.

Only behemoths such as 560-foot-long Ohio-class missile subs, which approach the size and tonnage of World War II aircraft carriers, benefit from such silencing so far. They're *very* quiet. "We're getting to the point where two of these [subs] could pass within 1,000 yards and not hear each other," said an anonymous sonar company executive in the early 1980s. Adm. Frank Kelso described the Ohio class as "probably the quietest submarine in the world."

At least one authority, *Jane's Defense Data,* suggests Seawolfs will use natural-circulation reactor cooling. "A quoted 'silent' speed of twenty knots suggests that reactor-cooling systems involve natural-flow circulation at least to that speed," the British publication notes.

Despite their quiet reactors, Ohios and all other nuclear-powered subs must silence another potent noise source: Expanding steam from the steam generator spins turbines at 6,000 to 7,000 rpm and turns gears. Because a vessel's propellers perform best at 200 to 300 rpm, turbine speed must be reduced. "You have to gear it down," said Kintner. "And gears whine; they're noisy. You make them to close tolerances to reduce their sound." Yet there is a stealthier and rarely used alternative to gears.

"You can get rid of them and use an electric-drive technique," Kintner said. If the turbine drives an electric generator, which is easier to silence, the electricity produced can then power a quiet low-revolution electric motor mounted at the stern and linked to the propeller.

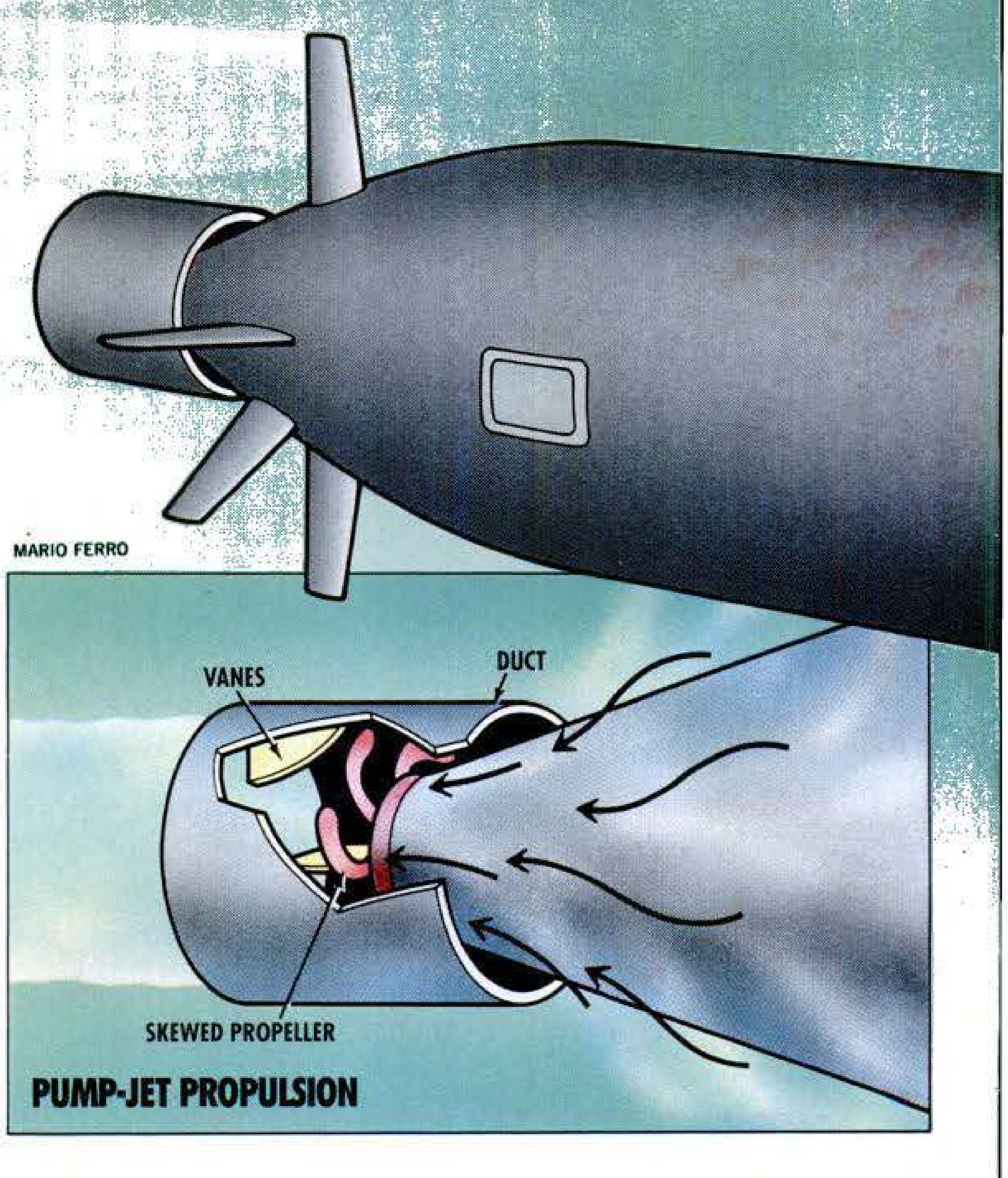
The Navy has built only a few of these turboelectric-drive submarines. It found the quieting demanded a price: speed. Motor technology of the 1960s and 1970s called for heavy steel components. As a result, the propeller drive motor had to be limited in size and horsepower to prevent the vessels from becoming tail-heavy.

"That's no longer the case," said a leading naval analyst who requested anonymity. "High power for electric drive at high speed is now possible with advanced composite materials for motors," he said. Such super-tough lightweight materials, which offer many advantages over steels, are used routinely in aerospace and other industries. Lightweight stern-mounted electric motors using these materials may appear in the new Seawolfs, offering the advantages of gearless propulsion.

When I boarded a Los Angeles-class sub moored in San Diego harbor, I thought of another major quieting innovation beneath my feet. Cmdr. Stan Szemborski, skipper of the U.S.S. *Chicago,* led me through a hatchway toward the control room and other unrestricted areas. "We've just finished loading weapons," he said as we passed a string of 20-foot-long two-ton torpedoes. These deadly underwater missiles, with orange-and-green warhead covers, knife through the water at 55 knots.

A key quieting technique in the *Chicago* and other new subs is acoustically isolated foundations known as rafts or bed plates. These are massive steel structures beneath the power-train machinery at the rear of the subs. Sound-deadening material isolates these rafts from the hull. The United States and Great Britain installed them during the 1960s, and the Soviets, apparently, in the late 1970s.

At the end of the sub power train, with its whining gears and whirring pumps, is the propeller. It too is a noise source. One source of propeller noise is water flowing back over the hull. Explains one analyst, who requested anonymity: "The flow of water at the stern isn't



MARIO FERRO

PUMP-JET PROPULSION

smooth. It's slowed behind the rudder and horizontal stabilizers. When a propeller blade hits that slow area, it's going to vary the pressure distribution." Similarly, if you blow air through a tube at whirling fan blades, the staccato sequence of short whooshes is much more noticeable than a steady flow of air.

Conventional propellers with a few broad blades resembling a clover leaf can create this staccato underwater noise. In a conference room near his office, the analyst sketches an unusual propeller design that solves this problem. It has many long and thin blades, each curved like a banana. "This is called a skewed propeller," he said. "It distributes the disturbances across the entire propeller area." Such propellers make less noise.

Rotating these propellers slowly and enclosing them in a duct or tube also cuts noise, the analyst explained. As propeller blades revolve, high-pressure areas form behind them and low-pressure regions develop on the front of the blades. As a result, at moderate depths, the pressure difference causes bubbles to form, especially at the fast-moving blade tips—a phenomenon called cavitation. The collapsing bubbles create a noise that becomes uncomfortably loud at high speed.

"Ducted propellers do several things for you," said the analyst. "They control the pressure at the blade tips and thus suppress cavitation." The duct surrounding the prop increases the pressure on the blade tips, reducing the bubbling and the noise. Also, if the ducted propeller draws water through a circular slot at the stern, he said, "you can reduce drag and narrow the ship's wake, while improving efficiency." Water near the hull flows neatly into the slot and feeds the propeller instead of forming turbulent eddies in a broad wake.

When a ring of stationary vanes called stators is added inside the circumference of the tube, the ducted propeller is called a pump jet. "The vanes straighten the flow in the duct," said the analyst. "This gives more thrust and reduces the wake vortices for a much less intense wake."

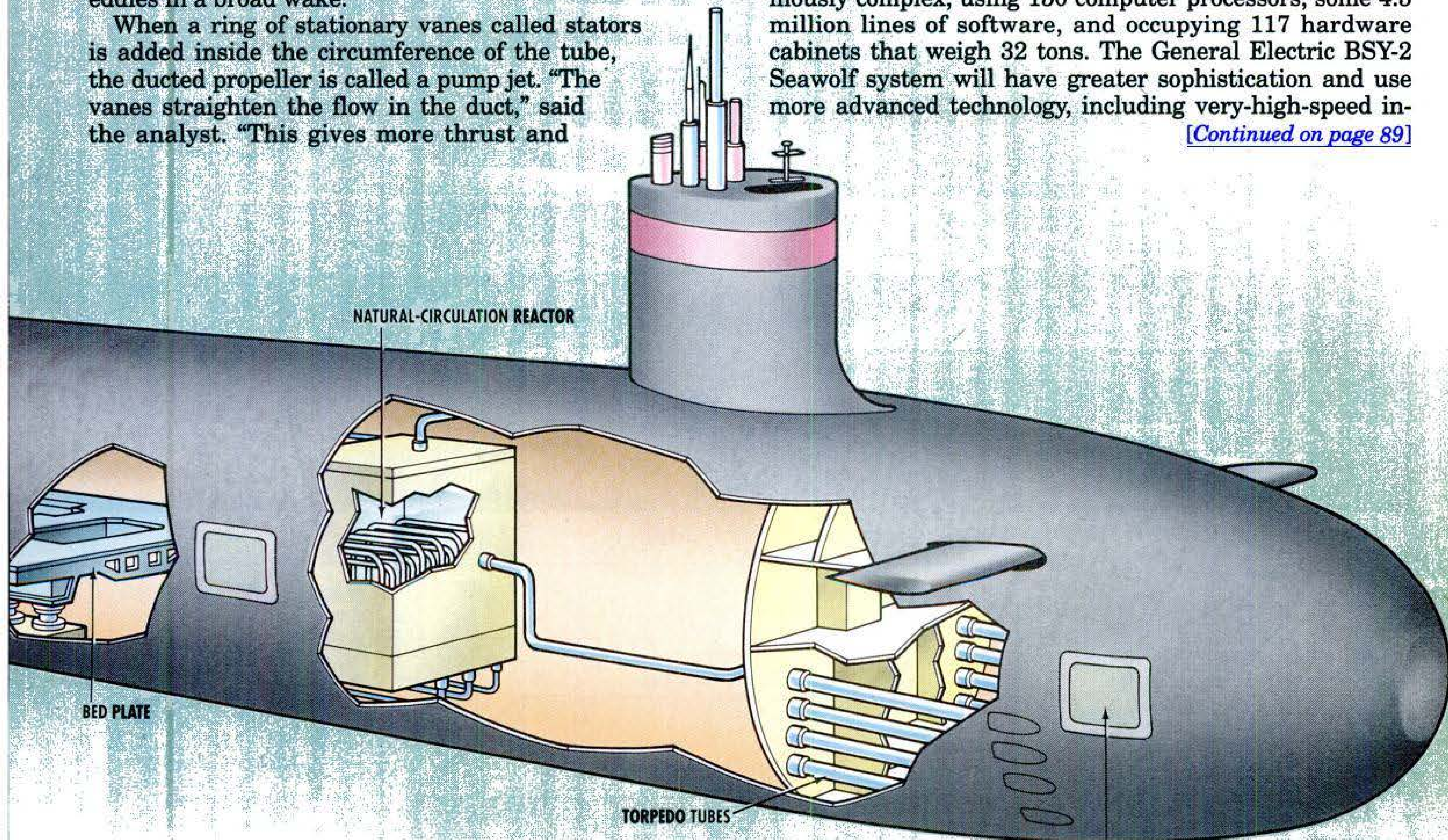
That's important, he said, because "you can pick up the wake with high-frequency active sonar." An enemy sub's high-pitched "ping" reflecting off the wake lets it follow the noise to the source. Norman Friedman, a physicist and Navy consultant, as well as *Jane's Defense Data,* claim that pump jets will be used on Seawolfs, providing extra stealthiness to help avoid such wake detection.

In combat, one major improvement from which Seawolf commanders will benefit, contrasted with older subs, is a high quiet speed. When a sub exceeds its top quiet speed, its own noise begins deafening its sonar. "If a boat becomes very noisy as it speeds up, that is a serious tactical deficiency," Adm. Kinnaird McKee, director of the Navy's nuclear reactors program, told Congress. "If you can go only ten knots before it begins to make noise, for all intents and purposes you only have a ten-knot submarine," he said.

According to *Jane's,* Seawolfs will develop some 60,000 shaft horsepower, nearly double that of the attack sub I visited. McKee claims that a Seawolf "will be quieter near its maximum speed" than a Los Angeles-class is "sitting alongside the pier." Estimates are that the 350-foot-long 10,000-ton-displacement Seawolfs will have a top speed of 35 knots and a top quiet speed of about 25 knots.

Los Angeles-class crew members graduating to Seawolfs in the mid-1990s will find similarities in the combat-control systems. Aboard surface ships, radar-based Aegis combat systems help sailors engage many enemy targets simultaneously. Similarly, on current 688 attack subs, IBM's BSY-1 combat-control system serves the same function, integrating data from several sonars. It's enormously complex, using 150 computer processors, some 4.5 million lines of software, and occupying 117 hardware cabinets that weigh 32 tons. The General Electric BSY-2 Seawolf system will have greater sophistication and use more advanced technology, including very-high-speed in-

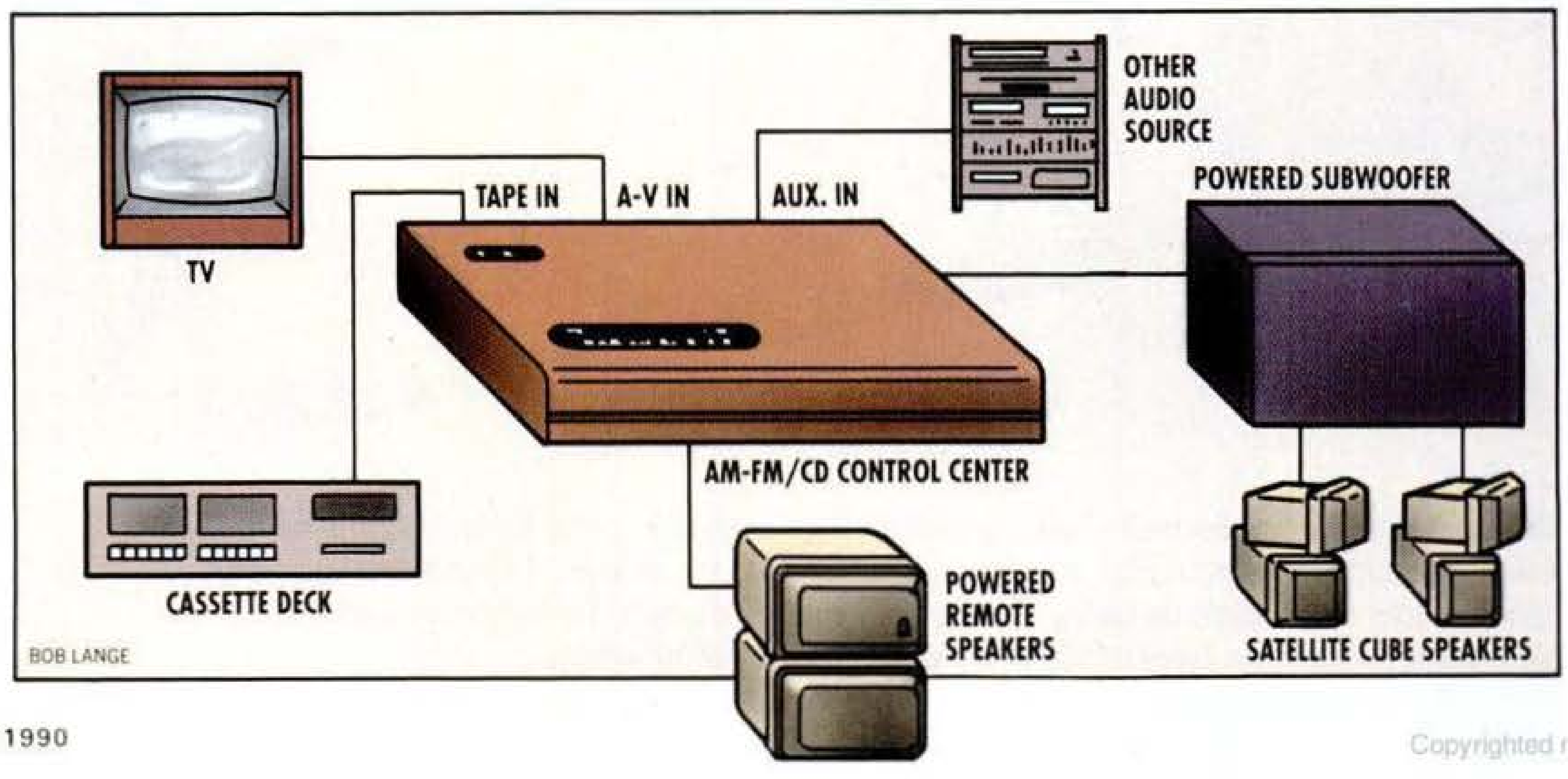
[Continued on page 89]



This artist's concept of a Seawolf attack submarine indicates curved propeller blades enclosed in a vaned duct. Such pump-jet propulsion systems boost efficiency and cut noise. A large natural-circulation nuclear reactor would eliminate cooling-pump noise at moderate speeds. Six hydrophones on the sides aid in triangulating target ranges. Eight tubes can launch a mix of 50 weapons.

JOHN B. CARNETT

Bose's Lifestyle uses the control center (bottom of picture), subwoofer bass module (near right), two cube-speaker arrays for mid- and high-frequency stereo reproduction (above subwoofer), and remote control (above control center) for the main listening area. The system's three power amplifiers—100 watts for the bass module and two 50-watt amplifiers for the cubes—are built into the bass module. Powered speakers are used at the remote listening area. The RF remote operates the system from anywhere. An additional remote costs $149.



BOB LANGE

STEREO FOR TWO

Listen to a CD in the den and a cassette in the bedroom; using a new multi-source system one stereo is all you need.

By LEN FELDMAN

Home entertainment systems are undergoing surgery that could be as radical as the switch from monaural to stereo: Now, instead of playing one source of music at a time, these new systems play two, and one plays more. You listen to FM-radio upstairs, for example, while downstairs someone else plays a CD. "It's like having two stereo systems in one box," claims Richard Paynting of Bose Corp.

Paynting is one of the designers of the Lifestyle, the first consumer audio system engineered specifically for multi-room listening. But the idea has competition: A trend has begun that already includes major makers such as Pioneer, Onkyo, and Carver, which are incorporating the multi-room concept into new stereo components.

The basic $2,400 Bose Lifestyle comes as a package that includes a speaker system for the main listening room (see drawing), a wireless hand-held remote, and a control center. The center contains an internal AM-FM tuner, a single-disc CD player, and three audio input connections for attaching external gear (tape, video, and auxiliary).

To make the control center work, you press buttons on the hand-held remote: The center receives your commands and starts a CD, changes the tuner's channel, lowers the volume, and becomes a clever electronic switch that routes one source of sound to the main speakers; another source to the second listening area. A $340 optional set of powered speakers (they contain their own amplifier) is needed at the remote listening area, and you connect them to the control center via coaxial audio cable.

Operating the Lifestyle center from the second location is simple: You use the same remote control. Unlike most remotes, which use infrared light and require you to be in sight of the stereo system, the Lifestyle remote transmits its signal to the control center via a radio signal (RF). "That lets you operate the system from anywhere in the house," says Paynting.

As a replacement stereo, or for people just now buying a system, the Lifestyle works well. However, its need for powered speakers and its use of an RF remote means that the Lifestyle won't mix easily with other conventional stereo components: Most speakers don't have a built-in amplifier, and most components use an infrared remote control. If you already own an audio system and wish to update it to multi-room use, there's still another way.

"You're listening to the soundtrack of a laser disc over here," says Mike Fidler, senior vice president for Pioneer, as he points to one side of a room at a demonstration of the company's new $1,350 audio-video receiver (see photo). "And you can hear the CD playing over there," gesturing to another set of speakers at the opposite end of the room. Then he presses a button on the infrared remote control and the two sources of sound immediately switch locations.

The point was clear: New stereo components give an existing system multi-room capabilities. Receivers from companies such as Pioneer and Onkyo contain the additional switching circuits and amplifiers to power standard speakers at the remote locations. And with the addition of an infrared link—an extension cord made of an infrared receiver at the remote location coupled via wire to an infrared transmitter at the stereo system—the standard remote control will operate the system from either location.

But "stereo for two" is in its infancy. Other makers are sure to have systems soon, and Carver is already thinking about bigger families. Its new MSI-1 Multi-Source Interface ($1,550) is designed to control up to five different listening areas. PS

Pioneer's VSX-D1S receiver can be added to any audio-video system for multi-room operation. Two listeners can choose from its five audio input sources and six audio-video inputs.

Friendship. Camaraderie. A sense of belonging. Those old feelings may be difficult to describe, but they're not hard to get back. Thanks to the Air National Guard.

In the Air Guard you'll learn what it's like to be a member of a winning team. It's also a place for individual advancement, too. Whether your aspirations are up in the air or more down to earth, we can help get your career off to a flying start.

Is telecommunications your calling? Maybe it's computer technology that's on your program. Meteorology, security, engineering...over 200 job opportunities can be pursued through the Air Guard. With comprehensive training to match.

We'll give you the chance to travel to exotic locations around the world. College tuition assistance through the Montgomery GI Bill. All with the good feeling of knowing you're serving your country. What other job can give you all that?

For as little as two days a month and two weeks a year, we'll pay you a great part-time salary as you serve in the Air Guard.

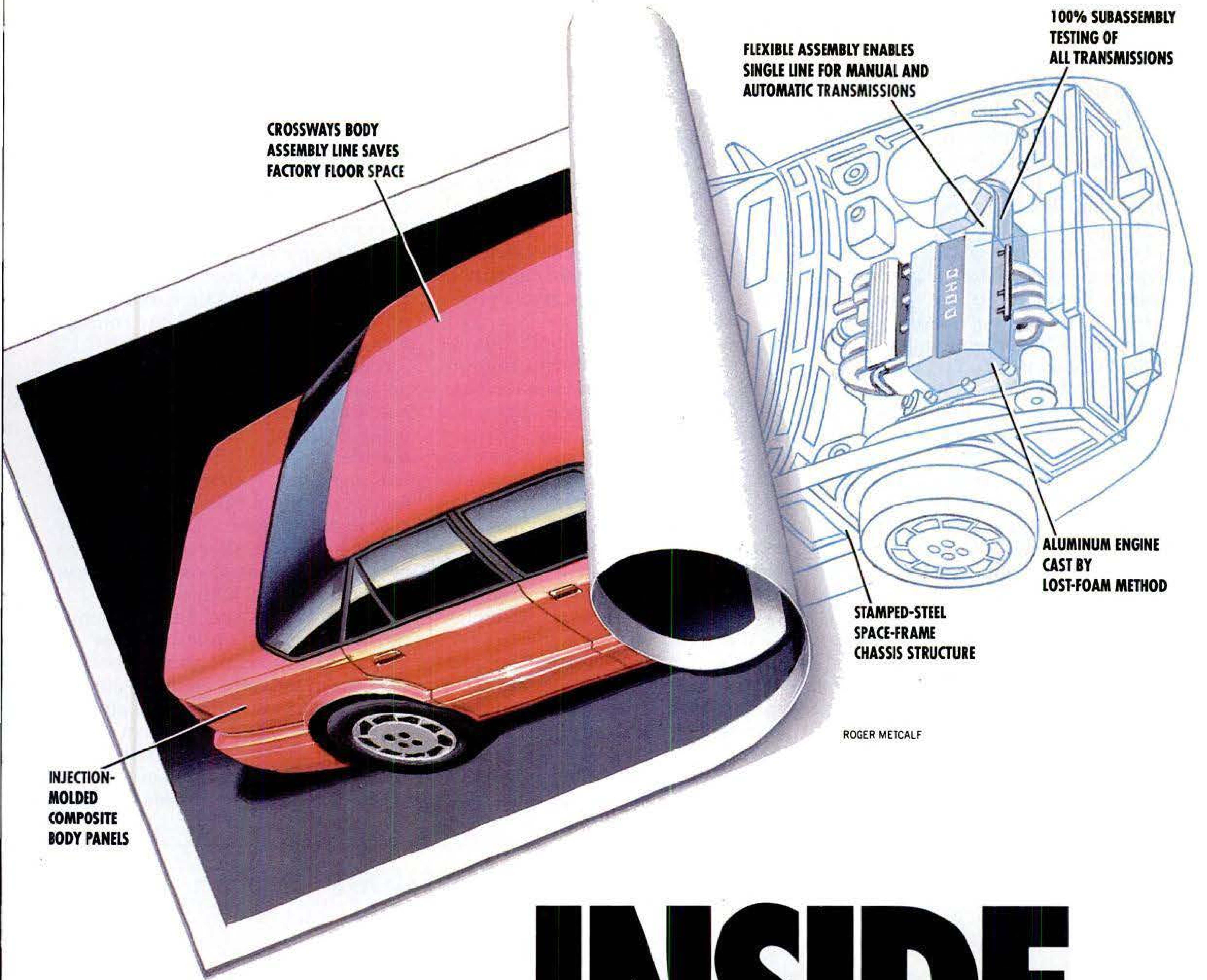
To find out how you can get your career off the ground, call the Air National Guard toll-free at 1-800-638-0936. We'll show you how to become one of the jet set.

Americans At Their Best.

AIR NATIONAL GUARD

A2PSBA**080NP

Copyrighted material


CROSSWAYS BODY ASSEMBLY LINE SAVES FACTORY FLOOR SPACE
FLEXIBLE ASSEMBLY ENABLES SINGLE LINE FOR MANUAL AND AUTOMATIC TRANSMISSIONS
100% SUBASSEMBLY TESTING OF ALL TRANSMISSIONS
DOHC
ALUMINUM ENGINE CAST BY LOST-FOAM METHOD
STAMPED-STEEL SPACE-FRAME CHASSIS STRUCTURE
INJECTION-MOLDED COMPOSITE BODY PANELS

ROGER METCALF

INSIDE SATURN

GM's radical new way to build cars.

By DAN McCOSH

A wary group of journalists gathered last fall at General Motors' Mesa, Ariz., proving grounds for its first close encounter with the car called Saturn. This group of auto writers, there to drive prototypes of the top secret GM import fighter slated for release late this year, had little reason to be optimistic. Collectively, they had seen Detroit auto makers fall short in one attempt after another at trying to outdo the Japanese in producing a high-quality, low-cost small car. "Sure, Detroit could build a car as good as the Honda Civic," went the gag among the pundits, "only who would buy it for $20,000?"

By the end of a long day driving on both the test track and public roads, the chortling was largely extinguished. Considering the mechanical specifications alone, there would have been little evidence to buoy hopes that Saturn will turn out to be GM's lifesaver in the high-volume small-car market. But back-to-back comparisons with the classic benchmarks from Japan favorably demonstrated the pluck and plushiness of the Saturns (see box, Saturn: First Driving Impressions). More surprisingly, the mechanical finesse of these prototypes was at a far higher level of refinement than anyone had anticipated.

Despite tight security at GM, the general configuration of the cars had been widely leaked: Front-wheel-drive coupes and four-door sedans would be first to the showrooms, each with four-cylinder power. Spy photos ["Automotive Newsfront," Dec. '87, Dec. '89] had revealed none-too-daring styling that could hardly be considered a breakthrough. In fact, the coupe and sedan were unmistakably GM in look, leaning heavily to the Oldsmobile/Pontiac school of design.

Digging deeper reveals interesting —but again, not breakthrough—technology. A space frame chassis with plastic body panels (like the APV minivans) will allow rapid styling changes. Both the engine block and cylinder head are cast of aluminum, using the lost foam process [April '86]. The 1.9-liter engine will be available in two flavors, a single-overhead-cam eight-valve and a 16-valve DOHC version. So far, the Saturn seems no better than on par with target competitors like the Honda Civic and Toyota Corolla; certainly it's not the 60-mpg wonder we may have dreamed about when the Saturn project (named after neither the planet nor the Roman god, but the Saturn rocket) was revealed in 1983.

"I'll drive the first Saturn off the assembly line before I retire," GM chairman Roger B. Smith said at the time in a Babe Ruth-style prediction, setting a deadline that allowed a bit more than six years to form a new corporation, set up an engineering staff, design an engine, transmission, and chassis, then plan and build one of the most complex manufacturing arrays ever undertaken by the auto industry.

So the question remained: How can GM, with a style of engineering development as rigid and traditional as West Point, build this car efficiently, equip it as well as the competition, and then sell it at a reasonable price?

The answer isn't simple, but our inquiries deep within the Saturn organization raised a number of possibilities. One factor is a centralized manufacturing operation that defies the conventions of modern-day production strategy. The soon-to-be-completed four-million-square-foot Saturn plant in Spring Hill, Tenn., reflects the fresh mind-set prevalent in the Saturn organization that makes itself felt in every issue from the union labor contract to the deployment of technology.

The notion of an everything-under-one-roof factory is not new, of course. Ford's River Rouge facility, not far from the urban decay of downtown Detroit, stands as an icon of the industrial might that once belonged solely to American auto makers. Built by Henry Ford in the opening decades of this century to stamp out Model T's by the millions, it was conceived as a self-sufficient entity, generating electricity on site and transforming the iron ore that came in one end into finished automobiles by the time it reached the other. Over the years, the difficulty of retooling production assembly lines for annual styling changes became too time consuming, and the ore-to-finished car concept was sidelined.

A new set of circumstances, though, makes a megafactory like Saturn economically feasible once more. "Computer modeling allowed us to design the plant around the process," says Saturn's vice president of manufacturing Guy Briggs. "There's not a front door and back door. Instead, we're set up to have the shortest distance between the point of receipt and the point of use for all materials."

On the plant floor, flexible manufacturing methods allow further efficiencies: Automatic transmissions come down the same assembly line as manual gearboxes, a first among U.S. auto makers. The basic design of the two transmissions allows the plant to alter the production flow of the two types, from 25 percent manual, 75

SATURN: FIRST DRIVING IMPRESSIONS

At its best, a car going through the gears has a harmony of precision and balance. For the driving enthusiast, a free-revving engine acts like an acupuncturist's pleasure point: Accelerating, it presses the seat back to your spine; the sensation eases as the rpm brushes past the torque peak, momentarily going g-negative as you tap the clutch and make a subliminal gearshift before getting back on the throttle. But how about when the grab for the gearshift feels like cracking the neck of a chicken? There is a point where engineering an automobile that exudes a sense of balance and harmony becomes a study in the black arts where sensation and emotion prevail. Up to now, such mechanical finesse has eluded many of the corporate giants that produce cars by the hundreds of millions, at low manufacturing costs, with some technical competence but little soul.

No wonder that skepticism prevailed among the small group of auto writers at GM's proving grounds in the Arizona desert last fall.

But the Saturn prototypes handled a strenuous workout with aplomb, cornering hard on an undulating pavement with solid steering, predictable balance, and none of the bob-and-weave expected of an economy car out of its element. The gearbox, in particular, was a short-throw bit of automotive pleasure that could be shifted with the thumb and index finger, coordinated with a clutch action as instinctive as tapping your foot at a square dance. In prototype form, the new Saturns conveyed an impressive sense of integrity and wholesomeness that has been lacking in GM's previous small-car efforts. Could it be that with all that anticipation, GM had, in fact, changed its ways? Although it was too early to answer that question fully, my brief test drive was the first solid evidence of just how far Saturn has changed the system.—*D. M.*

PRICE RANGE: $10,000 to $12,000
ENGINE: Aluminum 4-cylinder SOHC 8-valve; DOHC 16-valve
SUSPENSION: Independent front and rear
WHEELBASE: 99.5 inches—coupe; 102.5 inches—sedan
OVERALL LENGTH: 175 inches—coupe; 177.5 inches—sedan
EPA MILEAGE: 34 mpg combined city/highway

JOHN B. CARNETT

Foam casting polystyrene molds for the major engine components, held by Saturn vice president of manufacturing Guy Briggs, create accurate finished parts that require little finish work.

percent automatic, to 75:25 if there is a sudden change in demand. Similarly, the optional high-performance twin-cam engines are built side by side with the base engines, greatly cutting the cost differential.

This flexibility, engineered into both the basic design of the transmission and the manufacturing plant, is at the core of the Saturn's movement against the grain of past mass-production practice.

Implementing a flexible production line is not as simple as making the parts very much alike, according to Saturn's vice president for engineering Jay Wetzel. "The designs must be dissimilar to allow the production line tools to work. It's a real puzzle, and to solve it you have to put on your five-dimensional thinking cap."

Engine blocks, cylinder heads, and crankshafts are cast in the cavernous power-train building, using polystyrene molds that vaporize instantly when the molten metal is poured in, hence the term "lost foam casting." Even the raw materials delivery scheme is adaptable to market conditions: When the price is advantageous, Saturn's foundry pours a molten aluminum alloy delivered in vacuum trucks from an aluminum smelter across Tennessee.

The bottom line: Costs are lower because each cast part needs far less machine work, less material is wasted, and there's no need to clean casting sand out of the block's interior. Theoretically, the customer benefits because savings in the process and a lower initial investment in the factory can be redirected into raising the car's overall quality.

There are more subtle benefits as well. Lighter internal engine components produce smaller vibration forces, so the car feels smooth. The crankshaft is cast with hollow connecting rod journals and requires far less work to ready it for installation in the engine. Compared with GM's own two-liter four, the Saturn crank needs just 3.4 pounds of material removed in the machining stage as opposed to 10.4 pounds on the two-liter engine's shaft.

Early in Saturn's design stage, engineers examining the advantages of competing cars came to realize that previous GM efforts fell far short in the tactile sensations they provided to the driver. When the first Saturn design team sat down with a clean sheet of paper they wanted something better. Luckily, they weren't operating in a vacuum—a research project whimsically named the Mona Lisa program was just getting underway across the street from GM's technical center in Warren.

The Mona Lisa engineers were doing autopsies on the competition, in an ongoing effort to determine what the real benchmarks were for each component. The engineering group agreed that the best manual gearboxes to emulate weren't the Getrag-based designs in the top-level European cars (including BMW), but the transmissions built by Honda.

"People were buying a lot of Hondas," explains manual transmission engineer Warren E. Leet. "The action of the shift seemed to be more in the mainstream of what customers were looking for. Also, the basic design was simpler—with two rather than four shift rails [the guides that hold the gear-change mechanism]."

But targeting the best design wasn't enough. The transmission development program was working under the premise that from the driver's point of view it was the sensation he or she felt when working the gearshift that counted, not any individual component. Thus any piece of the linkage could become as important as a gear set or a technical choice such as using a cable shift linkage rather than rods. Easy to say, but this introduced hundreds of thousands of combinations of variables—leading to tinkering that could last for years.

That problem was addressed by a relatively new statistical method that allows analysis of multiple variables simultaneously. Called an orthoganal array, the method was originally developed by Dr. Genichi Taguchi, a Japanese engineering consultant, to analyze problems in a shoe factory. The methodology allows an engineer to estimate how much each part of a total system affects the whole. Applied to analyzing the entire trans-

GOING THROUGH SATURN'S GEARS

If you've mistaken the four-speed automatic transmission designed for Saturn (cutaway drawing below) for a manual gearbox, you are forgiven. After all, it's jammed full of conventional-looking gears rather than planetary sets, and there are gleaming rows of meshed teeth rather than impenetrable thickets of hydraulic circuitry.

Like a stick shift, the basic operating components of the automatic are two parallel shafts on which four constantly engaged gear sets are strung. First gear is linked to the main shaft through an over-running clutch that allows the gear to freewheel in one direction but not the other. Second, third, and fourth gears are each engaged by separate hydraulically actuated multiplate clutches. These function like the sliding synchronizer hubs and rings in a manual transmission, locking the gear to the main shaft when that range is selected.

Special actuator solenoids, taking direction from the computer that controls the engine and transmission, direct hydraulic pressure to the clutches to engage the proper gear set. The computer bases its choice on data gathered by sensors that read such factors as shaft rpm, road speed, and engine torque. Clutch engagement forces vary with driving conditions, as in all automatic transmissions, calling for crisper shifts at full throttle operation. Saturn's automatic makes the shifts smoother by adapting fuel-injection technology, however. The actuating solenoids vary the duration of the hydraulic fluid delivery by pulsing it on and off. Early attempts at using this technique were confounded by high noise levels generated in the circuitry. The solution came from GM's Hughes subsidiary, which lent some of its submarine expertise in quieting the hydraulics.

A handful of patents awarded to the transmission designers attest to their unique approach. The independent operation of the gear sets means that the timing of the shift from one ratio to another must be done smoothly. A pair of shaft-speed sensors measure shaft speed over one-eighth of a revolution to synchronize the shift action. Any misstep in the anticipated shift sequence actuates fail-safe modes that include a valving system and computer algorithms that call for skipping over a gear that doesn't engage properly. The same sensors prevent damage that could be caused by yanking the shift lever from neutral to first at high engine speeds with the car at a standstill.

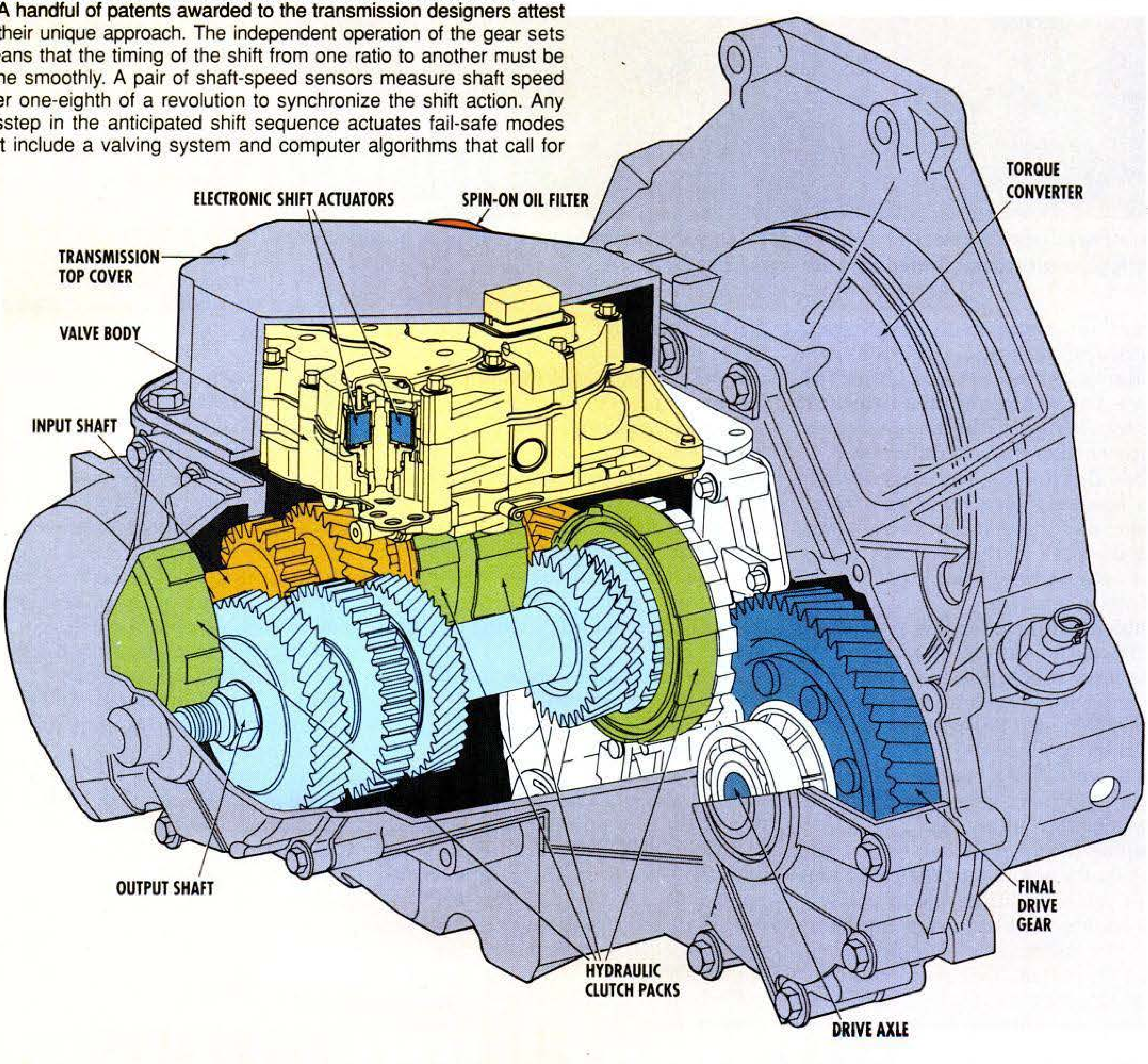
The control computer also senses deceleration, and bumps the throttle via the idle speed motor to make a so-called double-clutch downshift as the car decelerates. This action ensures the car is in proper gear when it exits a corner. Driving the automatic Saturn is eerily similar to making downshifts by hand.

Maintenance has been carefully considered too. The oil pan is on the top of the transmission, offering direct access to the valve body and routine service items. A spin-on fluid filter, easily reached on the outside of the transmission case, offers much easier upkeep as well.

The automatic's fraternal twin is the five-speed manual, which uses the same gear sets but almost no other mechanical parts. Gears are changed manually with a single-rail shift mechanism. The shift rail is the guide for a series of sliding forks that operate the moving parts. The single-rail design is controversial because some designs use as many as four shift rails to guide the shift fork smoothly as it slides the synchronizer hub back and forth to engage each gear. The Saturn gearbox relies on a fork that straddles several inches of shift rail, a design that stabilizes the fork.

Automatic and manual transmissions will be matched to the engine ordered; base engines will be mated to wide ratio gearboxes, and the high-performance twin-cams will be bolted to close ratio units.—*D. M.*

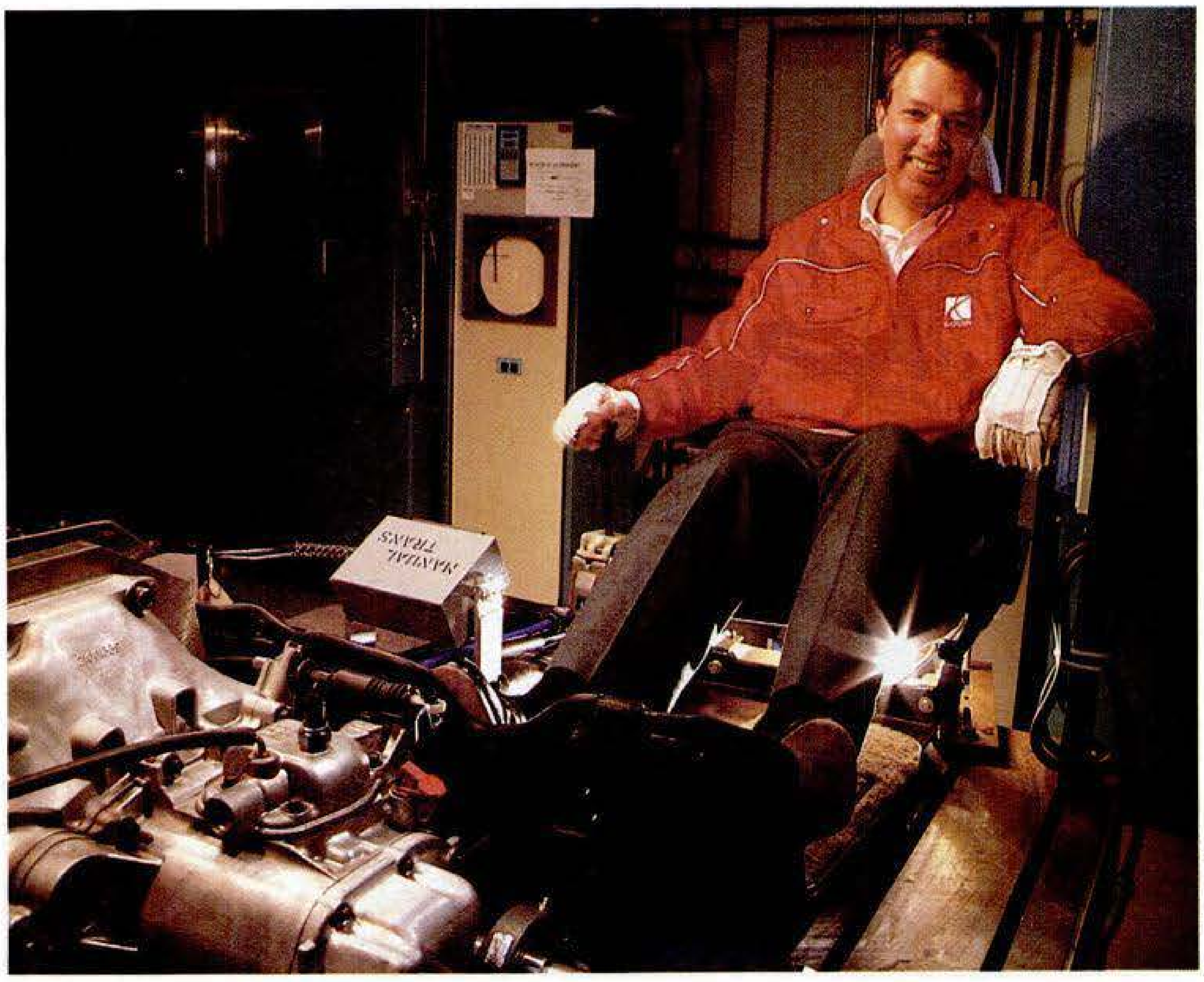
BILL DAVIS, JANET POIRIER, AND SATURN ART RESOURCE TEAM



mission design—from gearbox to shift lever—the Taguchi method vastly speeds the process of refinement.

The willingness of Saturn's development teams to question each component of the car is convincingly demonstrated by a gearshift development fixture built by a team headed by transmission engineer Mark Moehle. The engineers call this mockup of the car's interior a test buck; in reality, the contraption looks like an improbable dentist's chair in recline, with a gearshift knob that lands under your right hand as your feet rest on a metal plate. The plate shields an electrically driven transmission, connected with a makeshift linkage to allow fine tuning of the shift feel.

Using the test buck, the transmission team zeroed in on critical pieces affecting shift throw and feel. It wasn't unusual for the team to grab someone from the clerical department to come sit on the makeshift test arrangement for an outsider's opinion. Saturn's Wetzel put the process succinctly into perspective: "What is most important is that you don't get lost in your underwear trying to downshift."


JOHN B. CARNETT

Constant fine tuning of the gearshift feel on this rudimentary test buck (vice president of engineering Jay Wetzel at the handle) helped Saturn attain class-leading quality.

Using conventional mass-production techniques, the concept of a unique engine, transmission, and chassis for Saturn was a seemingly uneconomical way to go. Limited volumes of the components would be so expensive they would drive the cost of the "economy" car project through the ceiling. Wetzel recognized that as a two-edged sword—the drive train not only imparts the greatest degree of the car's character, it is also the area of greatest potential cost savings. "Designing our own power train was necessary to making Saturn a believable, stand-alone company," Wetzel readily acknowledges.

A drive-train design and dedicated factory that could quickly change with market demand seemed to be the answer. That way, production of even a low-volume manual transmission or a high-performance engine specifically for Saturn would be feasible.

In most cases, GM's previous efforts had been geared toward building huge volumes of standardized components, then re-engineering their installation in specific car lines. The system cut costs, increased the ability to turn out superficially new models quickly, and provided much of GM's competitive edge in the days when it threatened to dwarf its competition in the auto industry.

To appreciate the impact of the Saturn effort consider GM's giant Willow Run, Mich., transmission plant, originally built to manufacture B-26 bombers during World War II. The plant churns out more than a million transmissions a year, a volume that brings huge economies of scale. But that figure is some 10 times the sales of any particular car that uses it. The result often is that the car must be adapted to fit the transmission, and some GM cars need adapter plates to use the corporate "standard" transmission.

With the opportunity to construct their factory on a green field site, Saturn planners might have been expected to reach for highly robotized, lights-out production methods, using automatic guided vehicles to deliver parts and carry away completed units. The engineers' own experiences in earlier GM dabblings with such leading-edge devices had not been encouraging, however. So the emphasis was shifted toward maximum involvement of the Saturn factory workers in all processes of planning and implementation.

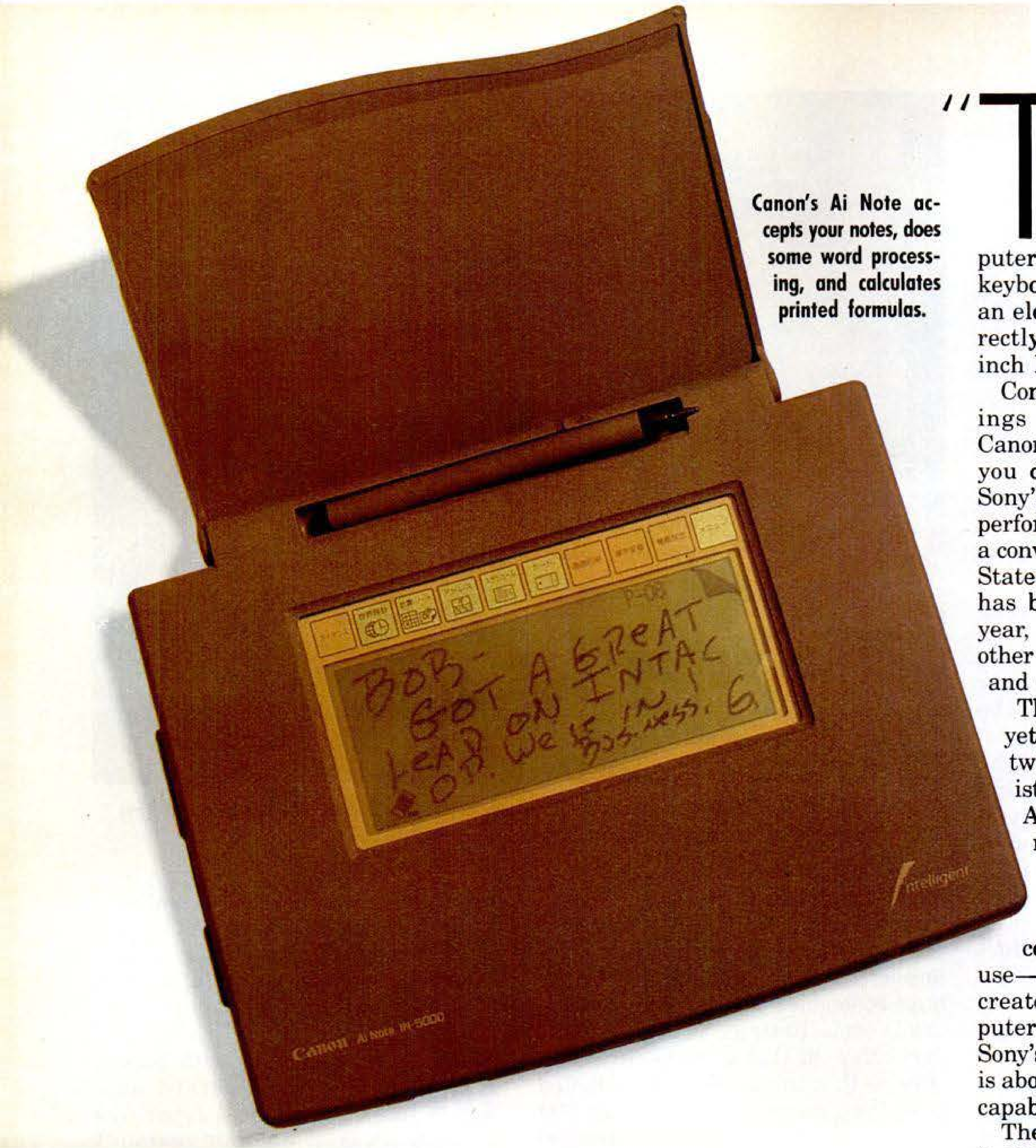
Still, the production methods break new ground in a number of areas. To save space inside the plant, car bodies move down the assembly line sideways rather than nose to tail. The transmissions come down their assembly line in any mix of automatic or manual, suspended on special assembly racks. The assembly area has been turned into an atmospheric high-pressure zone, forcing stray dust out of the area and off to less critical parts of the plant. The assembly line passes through a sophisticated checking station where every gearbox is tested before final sign-off. The transmission is run through the gears (automatics are shifted by air pressure), and faulty units are routed by computer back to a tear-down station for analysis.

My last encounter with Saturn was in a room packed with test equipment. A robot was clunking away at another gearshift lever, trying to shift through 80,000 miles of driving, the point at which a retaining ring had been working loose in tests. In the distance, doors were being slammed by other robots, as part of the relentless search for minutiae that makes up a new-car launch. It gave the feeling of an incredibly complex tailor shop, with each stitch being examined by Taguchi.

I climbed into the seat of the test stand for the transmission. Devoid of a car, I found that the gearshift lever indeed fell easily to hand, and with the electric motor turning the gearbox, you could get a sense of what it would feel like in the car.

There was something different about the place. It was smaller, more diverse, more like a village than the mega-engineering centers I had seen before. In a few months, the first cars produced at Saturn's Spring Hill factory would be on the road, which ultimately would be the test of whether this new mix of craftsmanship and technology really improves the breed.

I pulled the gearshift back into second and felt a pleasant "snick" before climbing down. PS



Canon's Ai Note accepts your notes, does some word processing, and calculates printed formulas.

COMPUTERS WITHOUT KEYS

No typing: If you can write, you can use any of these new computers. Take notes, ask questions, create graphics, or calculate data by writing directly on the screen.

By DENNIS NORMILE and J. T. JOHNSON

"This works just like paper and pen," says Tomoshi Hirayama, a Sony engineer who helped develop the new PalmTop computer. It's smaller and lighter than a notebook computer for a good reason: There's no keyboard. Instead of typing, you use an electronic pen to print or draw directly on the machine's four-by-six-inch LCD screen.

Computers that recognize your drawings and hand-printing are here. Canon has one called Ai Note that lets you do basic word processing. And Sony's new PalmTop comes close to performing some of the work done on a conventional computer. In the United States, Grid System Corp.'s GridPad has been available since early last year, and soon it could be joined by other machines from SuperScript, Inc., and Go Corp.

Throw away your keyboard? Not yet. Keyboard entry is still at least twice as fast for an experienced typist, according to a Canon estimate. And conventional character-recognition systems only understand printed, upper-case characters (see box). The advantage? Handwritten entry is a way to make computers smaller and easier to use—which manufacturers hope will create entirely new groups of computer buyers. How easy are they? At Sony's Tokyo headquarters, Hirayama is about to demonstrate the PalmTop's capabilities.

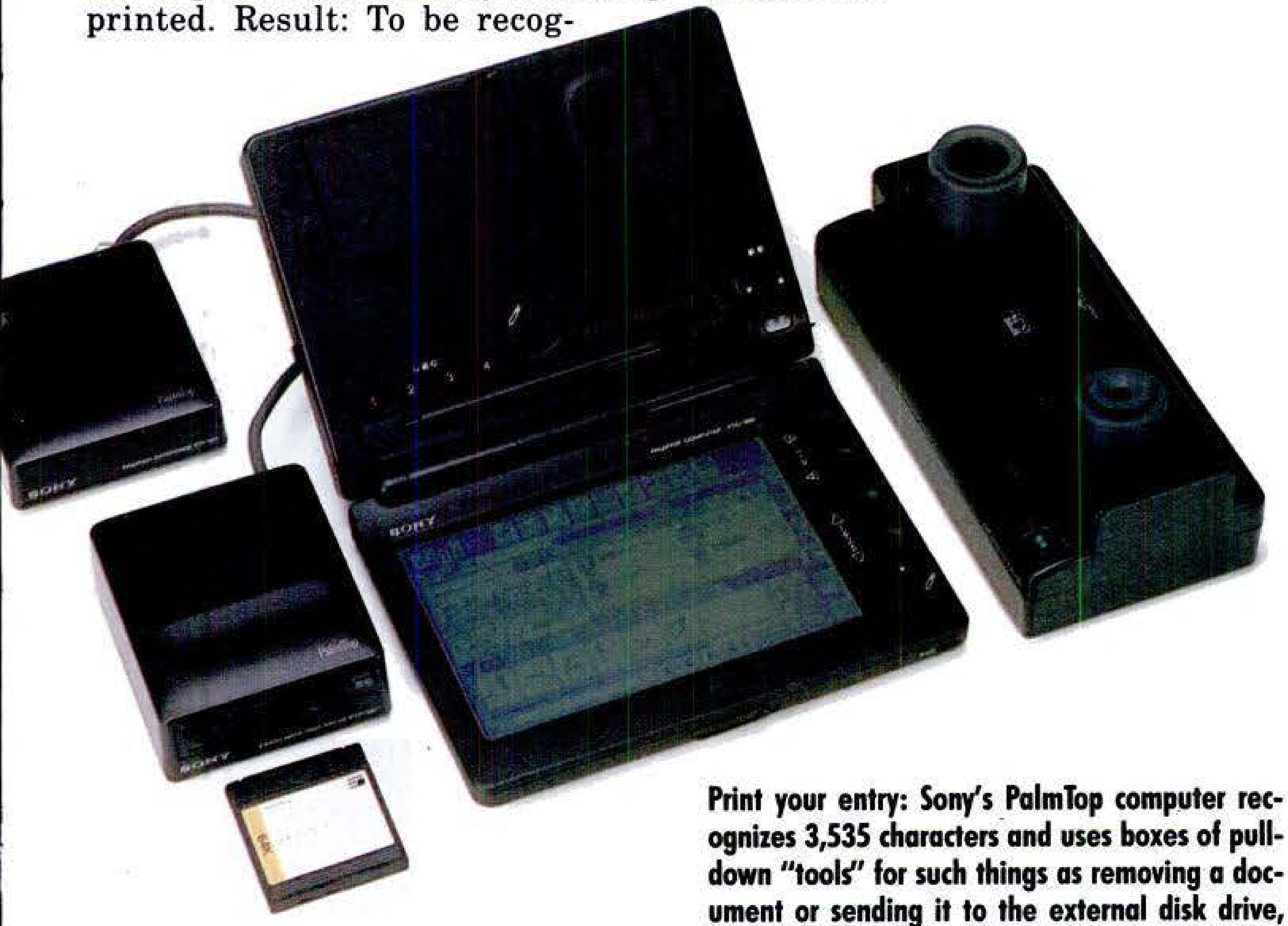
The center of the PalmTop's screen is empty, and along the top are tiny graphic pictures—icons—of "tools" you can use. For instance, touching the point of the pen to an icon of a calculator, Hirayama pulls it toward the middle of the screen. When he removes the pen, the face of a calculator explodes into view. Hirayama then uses the pen once again to touch the calculator's graphic keys to add some numbers together. The result is displayed across the face of the calculator, just as though it were real.

Hirayama then pulls a "typing plate"—a series of boxes—down to the bottom of the screen and starts writing letters, numbers, and *kanji,* Japanese characters, in the boxes. First the LCD screen shows exactly what Hirayama traces with his pen. But when he goes to the next box, the computer interprets what he has written, and redisplays the character for confirmation. Touching the pen at a transfer box sends the characters from the boxes to the main area of the screen.

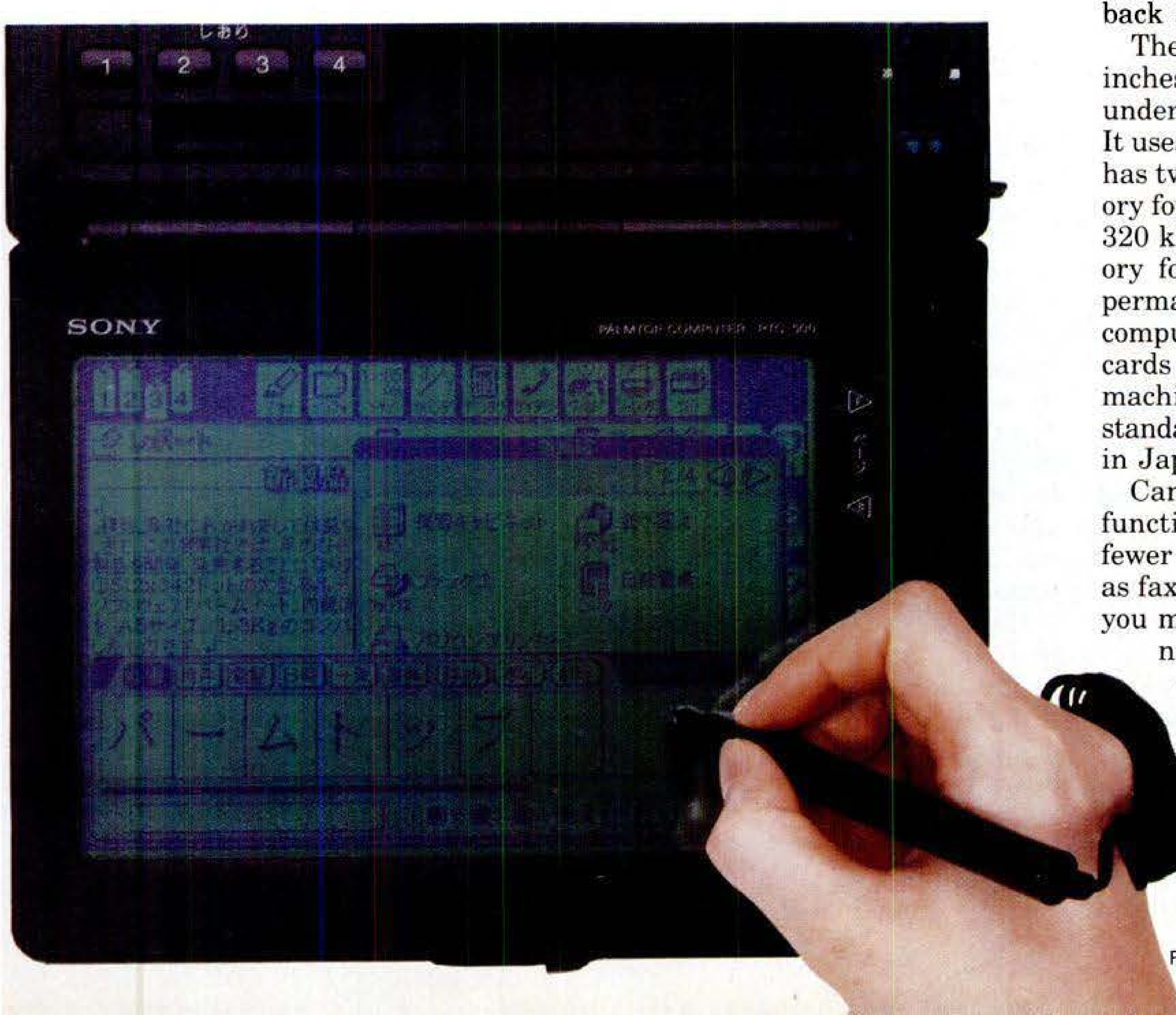
Next Hirayama touches a brush icon with his pen and fills the screen with doodles and script in lines both thick and thin. He draws circles and ovals and adds shadings. Then he connects a fax adapter, straps on a telephone handset, and sends the picture he drew to a fax machine in the outer office.

Impressive. But the keyboardless devices coming out in Japan are, for now, limited to the Japanese market, largely because of the way they read printing. Rather than recognize a character as a pattern after it has been written, as in conventional character-recognition systems, these machines trace the order, direction, and number of pen strokes as they are being printed. Result: To be recognized, a character must be printed in a precise, standard way—a writing technique "which all Japanese are taught," says Hirayama.

Engineers say the huge number of kanji used in Japanese left them no alternative. You need to recognize at least 2,000 kanji just to get through the newspaper. There are also two phonetic alphabets with 46 characters each, roman letters, and numbers. To make the PalmTop practical under those conditions, engineers had to design it to recognize 3,535 different characters.



Print your entry: Sony's PalmTop computer recognizes 3,535 characters and uses boxes of pull-down "tools" for such things as removing a document or sending it to the external disk drive, memory card, or fax adapter.



However, most people aren't so fussy about the procedure they use to print characters. That makes the PalmTop technique useless for other languages. Even within Japan, not everyone follows the rules. Hirayama says that in an in-house test, the machine correctly recognized 80 percent of the entries of 80 percent of the users on the first try. If the PalmTop misses, alternate choices appear below the boxes on the typing plate.

Trying them

Experimenting with the PalmTop and Canon's Ai Note for a few days proved they were so easy to use that the instruction manuals never needed to be opened. For example, to delete a document from the Sony machine, scan the row of tools and locate the "shredder" icon. With the pen, pull the shredder into the document and it's removed from memory. The machine doesn't take itself too seriously: There's animation as the document goes into the shredder and scraps of paper come out the bottom. And instead of a clock icon running while the computer executes a task, a turtle appears, huffing and puffing.

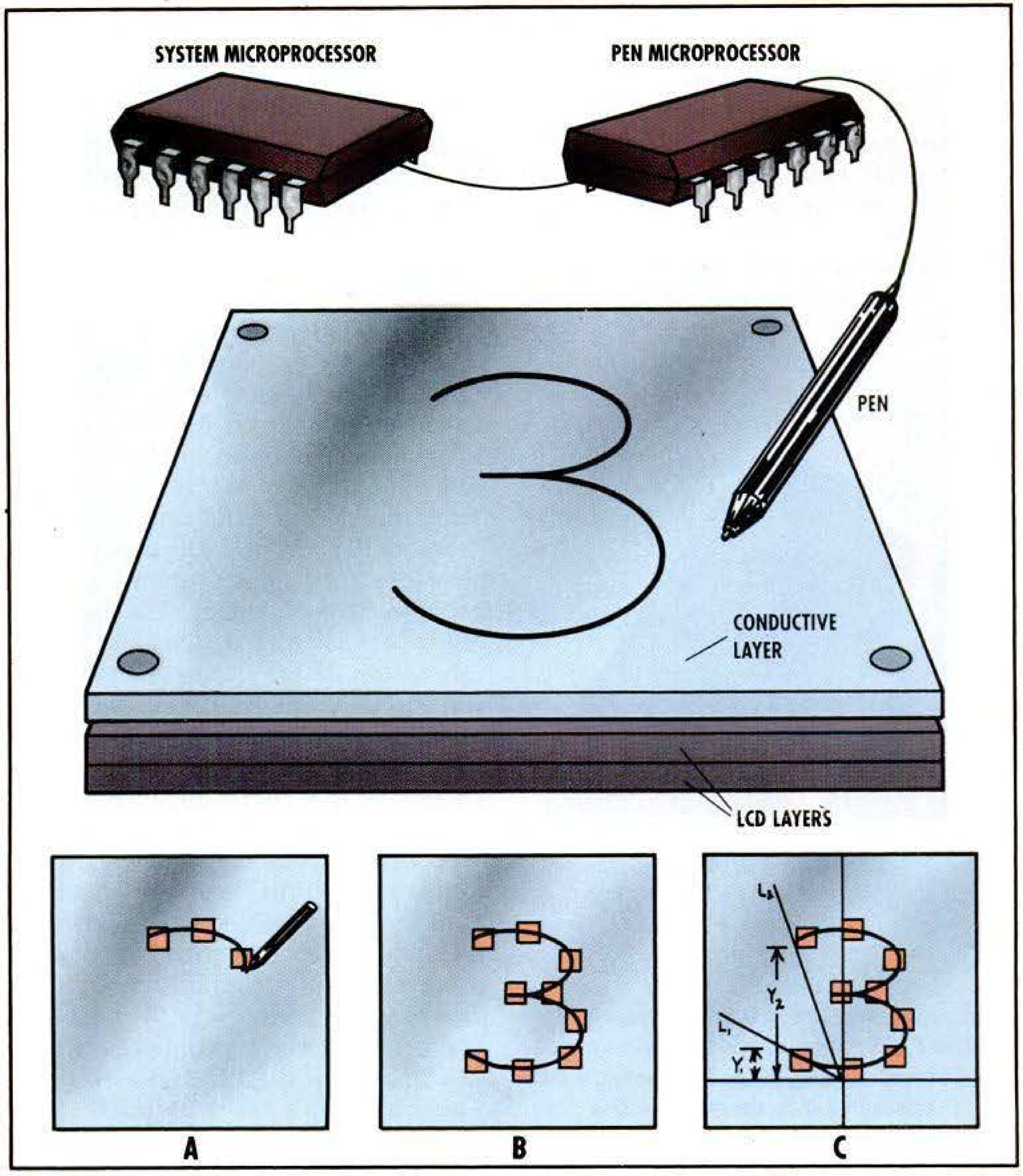
At present, the only software available comes built into the machine, which makes the PalmTop an advanced personal organizer with basic word-processing and graphics capabilities. However, its memory is also used for one other on-the-road application: It can become a digital audio recorder. The PalmTop's built-in microphone and speaker let you record and play back an eight-second voice memo.

The computer is 8.1 by 6.2 by 1.8 inches when closed and weighs just under three pounds with the battery. It uses a 68HC000 microprocessor and has two megabytes of read-only memory for holding internal programs and 320 kilobytes of random-access memory for temporary data storage. For permanently saving information, the computer can also transfer data to IC cards or a two-inch disk drive, and the machine can work with a variety of standard printers. It costs about $1,300 in Japan.

Canon's Ai Note has the same basic functions as the PalmTop but with fewer capabilities and no frills, such as fax adapters. It can't read kanji, so you must enter words using the phonetic characters. The machine then converts the characters to kanji, just like a typical keyboard-driven Japanese word processor.

Like the PalmTop, the stroke order is important even for numbers and roman letters. For example, the Ai

CHARACTER RECOGNITION: HOW IT'S DONE



BOB LANGE

For at least 15 years, researchers have been trying to develop machines that will recognize hand printing. The major obstacle: No one prints a character the same way every time. To a computer—accustomed to the exactness of data entry—understanding human printing is a formidable challenge.

For the new keyboardless computers, the recognition process begins at the LCD screen. The screen contains an additional layer of glass that is coated with antimony-tin-oxide—a transparent scratch-proof conductive layer of material. When the pen touches the surface, it completes a circuit that allows a microprocessor to determine the pen's vertical and horizontal position. Those data are first used to turn on the pixel at that location, and a single dot appears under the pen (box A). As the pen is moved, more pixels turn on at the appropriate locations, making it appear that the pen is drawing the lines of a character (box B).

Although the character is displayed on the screen, the computer must now determine what those lines mean. To do it, a special character-recognition program is used—but this type of software can work in a variety of ways.

Traditional character-recognition software uses the coordinates data as a series of points falling along a line (box C). Then, using an algorithm—a predetermined formula—the program evaluates those dots in terms of their distance from the letter's base line and the angle relative to the perpendicular. After calculating the distances and angles for all the points, the computer then compares the sum with a table—a template—of possible characters. When the nearest match is found, the software reprints the character it has found for your verification.

The difficulty of this approach is that tem-

Note only accepts zeros written counterclockwise; write a zero clockwise and the machine thinks it's a two.

The slickest function of the Canon machine is the calculator. Write a mathematical equation as you normally would on a piece of paper, including brackets, powers, and roots. Then, as soon as you print the "equals" sign, the machine performs the operation and gives the answer.

The Ai Note is slightly longer and wider than the PalmTop, but is less than an inch thick and weighs less than 25 ounces. It's about $500.

New users?

Handwritten entry devices are likely to create new uses for computers. One possibility under study at Fujitsu Ltd. is a system for bank customers to enter data directly into a computer when opening an account or transferring funds, eliminating written forms.

"A keyboard just doesn't suit all the people who come to a bank," says Kazushi Ishigaki, a researcher at Fujitsu's Human Interface Laboratory.

In the United States, Grid has been aggressively seeking new uses for its $2,370 GridPad computer introduced last September. The computer uses an 80C86 microprocessor, so it's compatible with any PC-DOS program, including those requiring displays in the graphics mode (640 by 400 pixels). And the 4½-pound book-sized device can also accept an external keyboard and has an internal modem for conventional computer work.

However, the Grid's strengths are its ability to recognize characters quickly in nine different languages—including French and Danish—and its clever use of graphics to display fill-in-the-blank forms that anyone can use.

The forms are initially developed on any MS-DOS computer. To create one, Ken Dulaney, Grid's director of advanced systems marketing, gave a demonstration using the company's Grid-Pen Applications Program Interface. Although he warns that it usually takes an experienced programmer many hours of dedicated work to create a usable form, within seconds Dulaney began creating a subscription form for Popular Science and other magazines.

Do-it-yourself form

"We had to write our own program because this is such a new field there's nothing on the market to deal with handwriting recognition," he says, as he starts dragging graphic boxes into place on the screen.

"What do you want to have permanently entered in this box," he asks? I type Popular Science. As I watched, Dulaney had soon created a fill-in-the-blank magazine subscription form ready to be sent to a GridPad for instant use by the Popular Science subscription department.

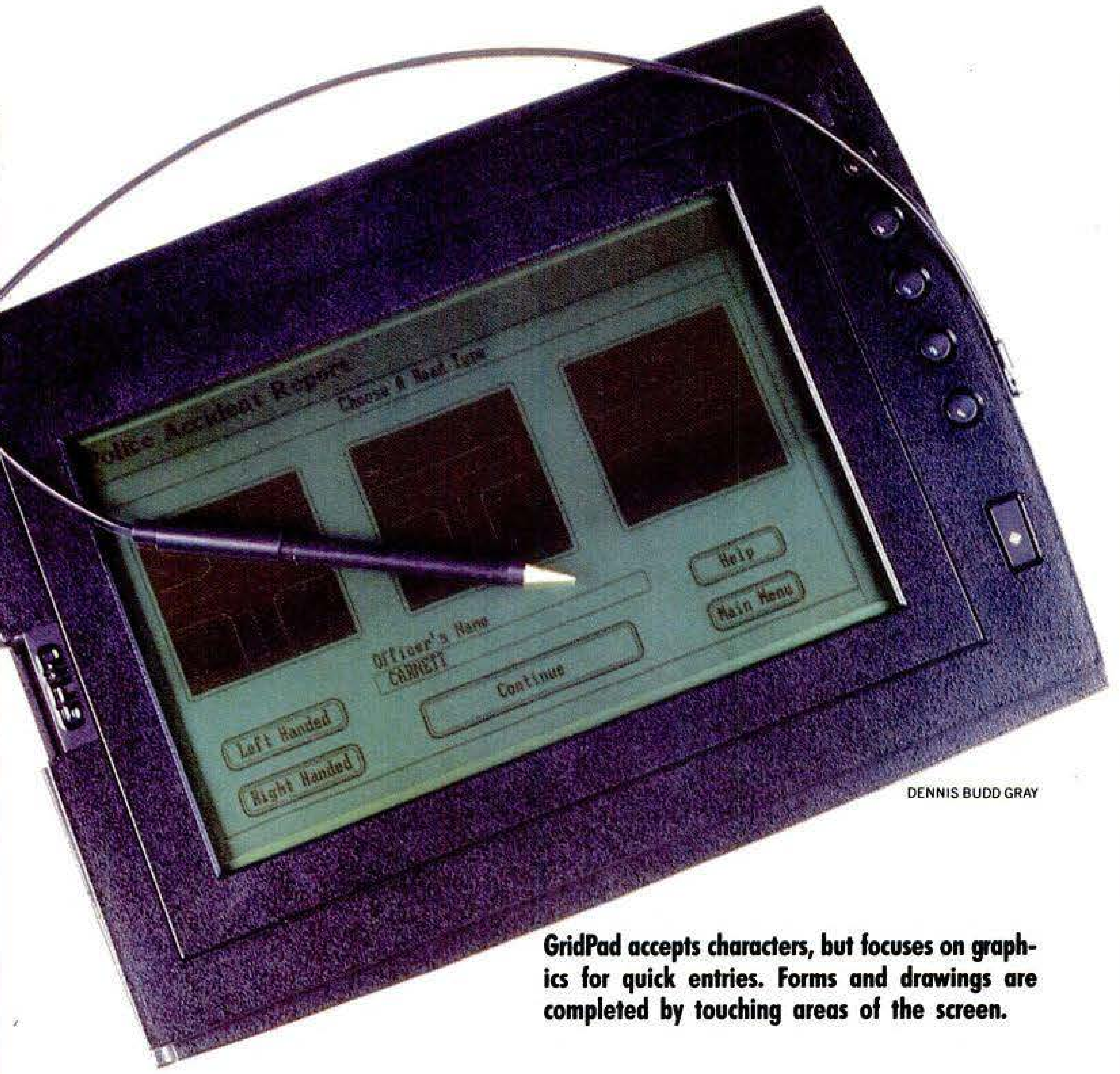
plates for all the possible characters use as much as 400,000 bytes (400K) of memory, and a program trying to leaf through all that for a close match operates slowly. It could take a few seconds or more for each entry.

To speed the recognition process, Jeff Hawkins, director of Advanced Programs at Grid Systems Corp., used his background in neural networks to take a different approach.

Hawkins' solution was to expose his recognition system to a collection of 3,000 handwriting samples and let the software create just one piece of information for each character to be recognized. That keeps the memory size small and the speed high. In a recent demonstration, Hawkins moved the pen across the computer's screen to print the letter "A" with fast, bold strokes. Indeed, within 0.3 second the computer responded correctly with an A on the LCD. "No matter how many characters or symbols you expose to it, the memory requirements won't expand much above the five kilobytes now used," Hawkins says.

Because of the enormous number of symbols in the Japanese language, templates of completed *kanji* characters would be too large to be practical. So the PalmTop uses dynamic recognition—the pen movements are analyzed by the software as the character is being drawn. Using fuzzy logic [July], each movement is compared against templates of the order, direction, and pen strokes for a match. The system relies on every user creating a character in the same way.

In general, characters to be recognized by any of these new computers must be entered in some form of graphic box. The box keeps the size of the character you write to within tolerances of the recognition software. Future versions could recognize a character of any size, anywhere on the screen. And even later versions might recognize script writing.



DENNIS BUDD GRAY

GridPad accepts characters, but focuses on graphics for quick entries. Forms and drawings are completed by touching areas of the screen.

The form could be used by a sales department to take a subscriber's name, address, and the number of years for the subscription easily and quickly, and then calculate the price. That information could be sent to a computer in the magazine's circulation department. (Grid is already thinking about how to do this via cellular phone or other low-power radio systems.) A first issue could then soon be on its way.

Using this idea, a variety of new computer users could be created. For example, truck route drivers could use a computer to inventory their products on a store's shelves quickly, write a new order, have the store manager sign for it, and save it all in memory. Once back at the office, the numbers and handwritten notes would be sent to the company's computer for inventory control, manufacturing, and accounting.

A traffic cop can draw a sketch of the intersection where an accident occurred, insert the details of which vehicle was traveling in what direction, make notes on the sketch, and link the graphics file to a driver's data-base record. At the end of the shift, the report is sent to the records division and the officer goes home—no more hours spent hunting, pecking, and shuffling carbons.

Although the number of uses for keyboardless computers seems to be growing, experts believe more work must be done, and it will be some time before they are accepted by everyone. "Current displays are hard and slippery," says Fujitsu's Ishigaki. "If they don't have the same feeling as writing on a piece of paper, they won't gain acceptance."

But this is just the start. While the PalmTop, Ai Note, and GridPad computers are available now, they are just the first of what could be the next evolution in personal computing.

More to come

"It will look like a clipboard," says Zyg Furmaniuk, director of marketing at SuperScript in Cambridge, Mass. The company is in the planning stages for what it calls the Companion, a keyboardless computer to be shown later this year.

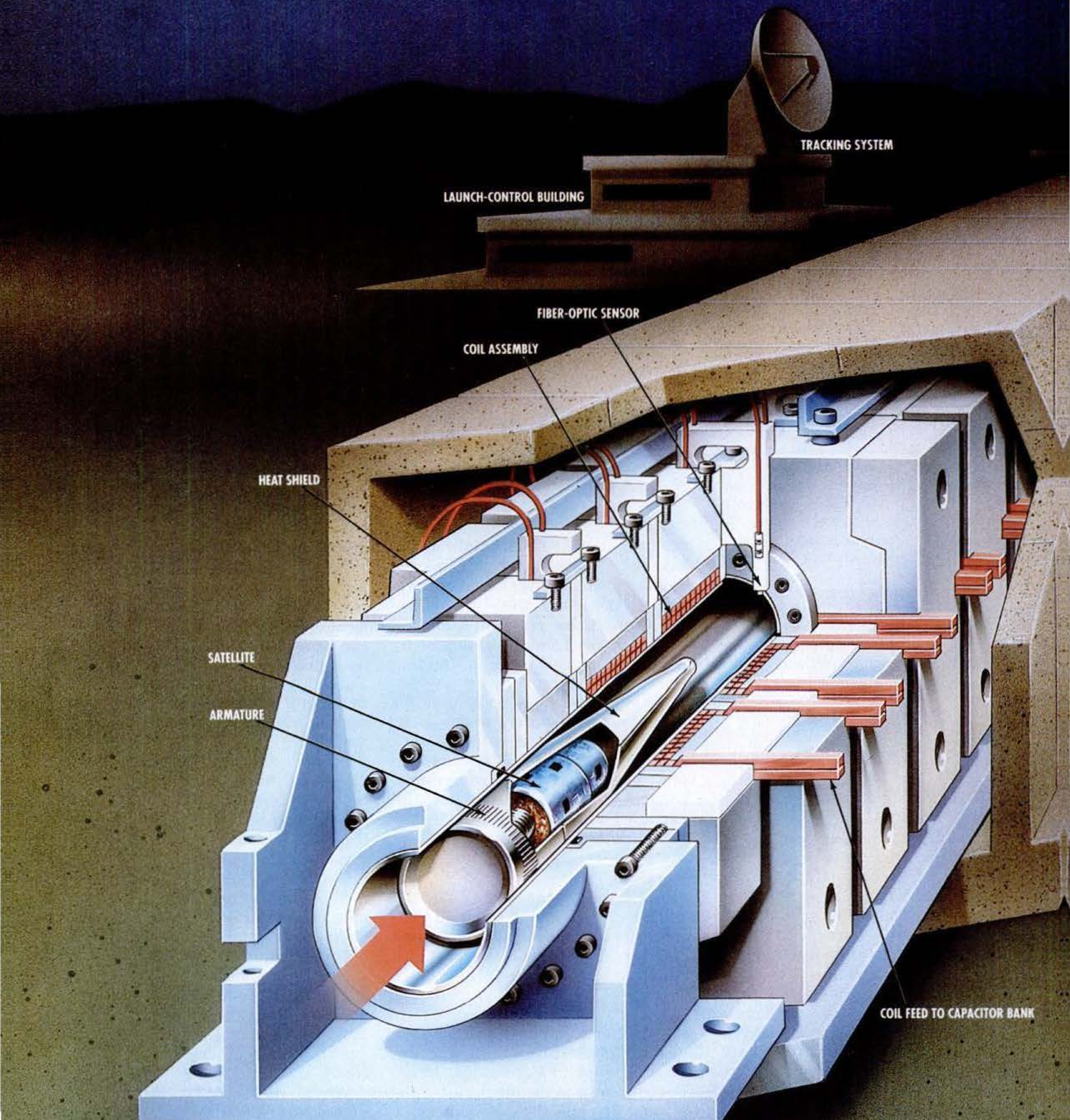
According to Furmaniuk, the prototype accepts printed characters, but the company is working on ways to read written entries also. In order to quicken the analysis and work, the system uses a high-speed RISC processor and the UNIX operating system.

"But character recognition would only be done when needed," says Furmaniuk. He expects the unit to be used more for graphics storage. "You can write on it as you would note things on paper," he says. After that, claims Furmaniuk, "your note could be saved in the unit's 200,000-page memory for recall later or even sent to a fax machine."

Another company, Go Corp. in Foster City, Calif., has recently caught the attention of computer watchers. "Officially, we will have a product sometime this year," says spokeswoman Carol Broadbent.

Unofficially, Go has a 4½-pound one-inch-thick machine that will be available in the fall. It will use an 80286 microprocessor with up to eight megabytes of memory, have high-quality video, use an unattached pen for more freedom, and, according to industry analyst Richard Shaffer in his "Computer Letter" newsletter, "It will be the most talked about new computer since NeXT."

Why all the fuss? Supposedly, the Go unit is backed by IBM and will have a new recognition system more tolerant of human printing than anything else in use. Upper-case and lower-case characters will be recognized and you'll be able to write them anywhere on the screen. That lets you quickly enter an entire word or group of words—just like using a pen and paper. PS



Straight shooter: Sandia's electromagnetic launcher would put satellites into polar orbit without using Earth-based rockets. In this full-scale artist's concept, the 2,034-foot flyway comprises 3,200 stages and is tilted at a 30-degree angle. The projectile is made up of an armature (at the rear) and the payload covered by a pointed heat shield. Magnetic induction provides the propulsion, and there is no contact between the projectile and the barrel. Each coil section is energized sequentially by high-power capacitors, controlled by optical sensors.

SATELLITE CATAPULT

Is there a practical alternative to launching satellites with chemical rockets? Maturing coil-gun technology may be the answer.

By TIMOTHY O. BAKKE

Since 1232, when residents of the Chinese provincial capital of K'ai-feng surprised their Mongol attackers with "arrows of flying fire," the general principle behind rocket launching has remained the same: Newton's law of action and reaction. Even Titan rockets are, in some ways, a crude technology.

Filling a huge cylinder with explosive fuel, pointing it at the heavens, and igniting it is always somewhat risky. The process has a two- to four-percent failure rate according to most rocketry experts. Besides, rocket launching is time-consuming, taking anywhere from months to a year between events; and it is expensive, from a few thousand to tens of thousands of dollars per kilogram on orbit, depending on the size of the rocket. Generally, the smaller the rocket, the higher the per-kilogram cost to launch a payload.

Though we have no replacement for large rocket launchers yet, Sandia National Laboratories in Albuquerque, N.M., has what it thinks is a better idea for launching lightweight communications satellites: an Earth-based electromagnetic gun that would shoot the small spacecraft above Earth's atmosphere. "The technology uses electromagnetic induction to accelerate a projectile," says M. Bill Cowan, manager of Sandia's Advanced Energy Conversion Systems Department. "We anticipate being able to launch small satellites, up to about 400 kilograms [882 pounds], within ten years."

The launcher is not without its technological problems, to be sure, but it would be safer than rockets because there is no explosive force involved. It would be reusable, able to launch satellites thousands of times—every 10 minutes when necessary. Electromagnetic launching would also be cheaper, on the order of hundreds of dollars per kilogram on orbit versus thousands during its useful lifetime.

Electric launchers were first conceived of in the 1920s. They remained primarily a theoretical curiosity for almost 50 years. The propulsion system exploited the Lorentz force, which is the force exerted on an object moving in an electromagnetic field. In simplest terms, if you joined two

Fast. Or Free. Guaranteed.

When you drive into your GM dealership for a Mr. Goodwrench Quick Lube Plus, you know you'll get three things: Good parts. Good 'n fast. And a good price.

Mr. Goodwrench uses GM Goodwrench Motor Oil and AC Oil Filters. The right weight of oil for your kind of weather. And the right oil filter for your kind of engine. Plus, you get a complete 10-point maintenance check.

You also get Mr. Goodwrench's Fast or Free Guarantee: *If you're not in and out in 29 minutes or less, your next oil and lube is free.**

Mr. Goodwrench Quick Lube Plus. Now at participating General Motors dealerships, wherever you see these signs.

CHEVROLET PONTIAC Oldsmobile BUICK Cadillac GMC

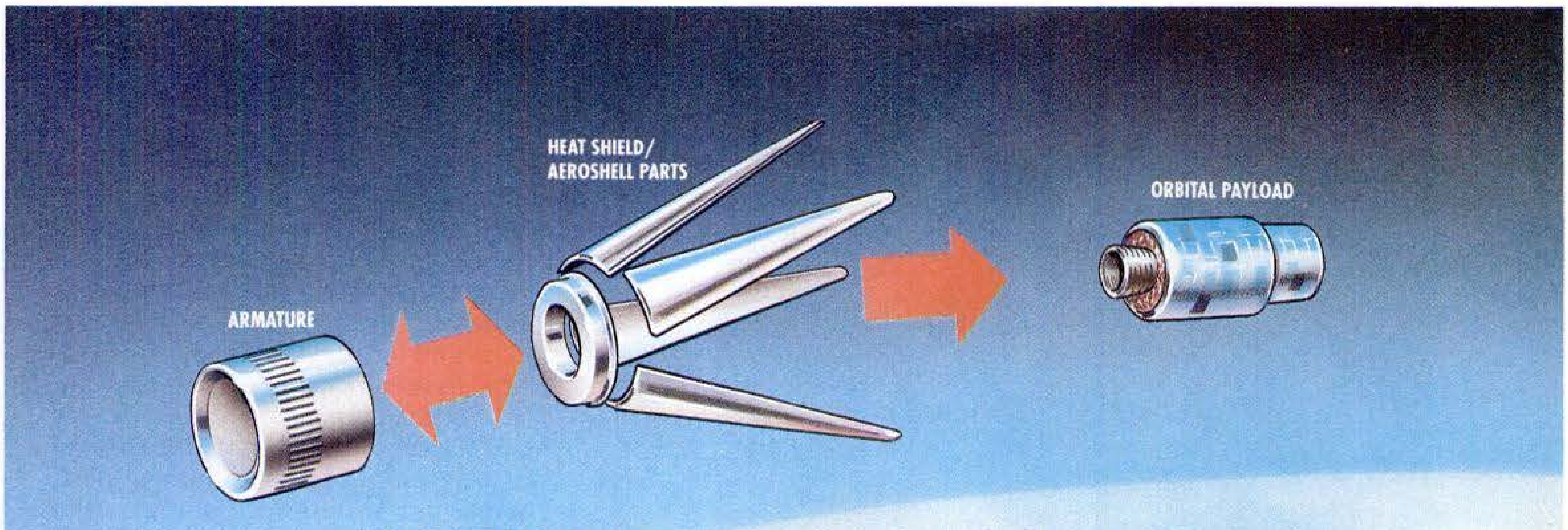
Now at GM Dealerships.

Mr. Goodwrench
QUICK LUBE plus
29 MINUTE GUARANTEE
OR THE NEXT ONE IS FREE

---

*29-Minute Guarantee applies to GM cars and light trucks.

©1990 GM Corp. All Rights Reserved.



SHOOTING A SATELLITE INTO LOW-EARTH ORBIT

The satellite-launching system envisioned by Sandia National Laboratories is actually a hybrid, combining an electromagnetic accelerator and above-atmosphere rocket firing. The contactless coil gun is designed to launch satellite-bearing projectiles above Earth's atmosphere at a speed of at least 2.8 miles per second, more than 3½ times the speed of a typical rifle bullet. Shortly after launch, the cylindrical armature would separate and drop away like a conventional rocket's first stage. Likewise, the heat shield would break away once the projectile escapes Earth's atmosphere. Then a booster in the satellite would fire to provide the additional velocity —another 2.8 miles per second—needed to achieve polar orbit. Inertial navigators aboard satellites would control these latter stages. The launcher could be used to install SDI's Brilliant Pebble concept—a network of small low-Earth-orbit satellites, each being an autonomous interceptor that would have enough computer capability to be able to handle battle management. A similar network of commercial satellites could make point-to-point cellular phone communication possible anywhere on Earth.—*T. O. B.*

conductors with a sliding armature and connected them to an electric power source, you would generate a magnetic field. The interaction between the field and the current in the armature would drive the armature ahead, with a force proportional to the square of the current. Unlike conventional guns, whose speed is limited by the expansion of gases caused by an explosion, electromagnetic guns would theoretically be capable of achieving Earth-escape velocities—more than five miles per second.

Engineering problems like storing and transmitting sufficient electromagnetic energy for super-high-speed propulsion thwarted the building of such accelerators until the 1970s. Since then, mostly because of increased research funding by the U.S. military, electromagnetic launchers have been developed—with an eye to making them into super-artillery guns ["Electromagnetic Guns," Aug. '87]. They have evolved in two directions: rail guns and coil guns. In rail guns, huge jolts of electricity are delivered to parallel metal rails, creating a magnetic field (usually through the formation of plasma, clouds of gas with electrical properties) that propels projectiles at great speeds. The guns have achieved muzzle speeds about nine times faster than that of a bullet. Because of their design, however, they are at least partially destroyed each time they are fired.

Coil guns produce traveling magnetic waves that accelerate projectiles. They use stacked coils instead of rails, and can fire rapidly and repeatedly. The Sandia launcher is called a contactless coil gun.

"In our launcher the projectile passes through a series of coils that forms a barrel, or flyway. There is no sliding contact on the sides of the tube," says Cowan. The contactless aspect of the gun avoids the durability problems of rail guns.

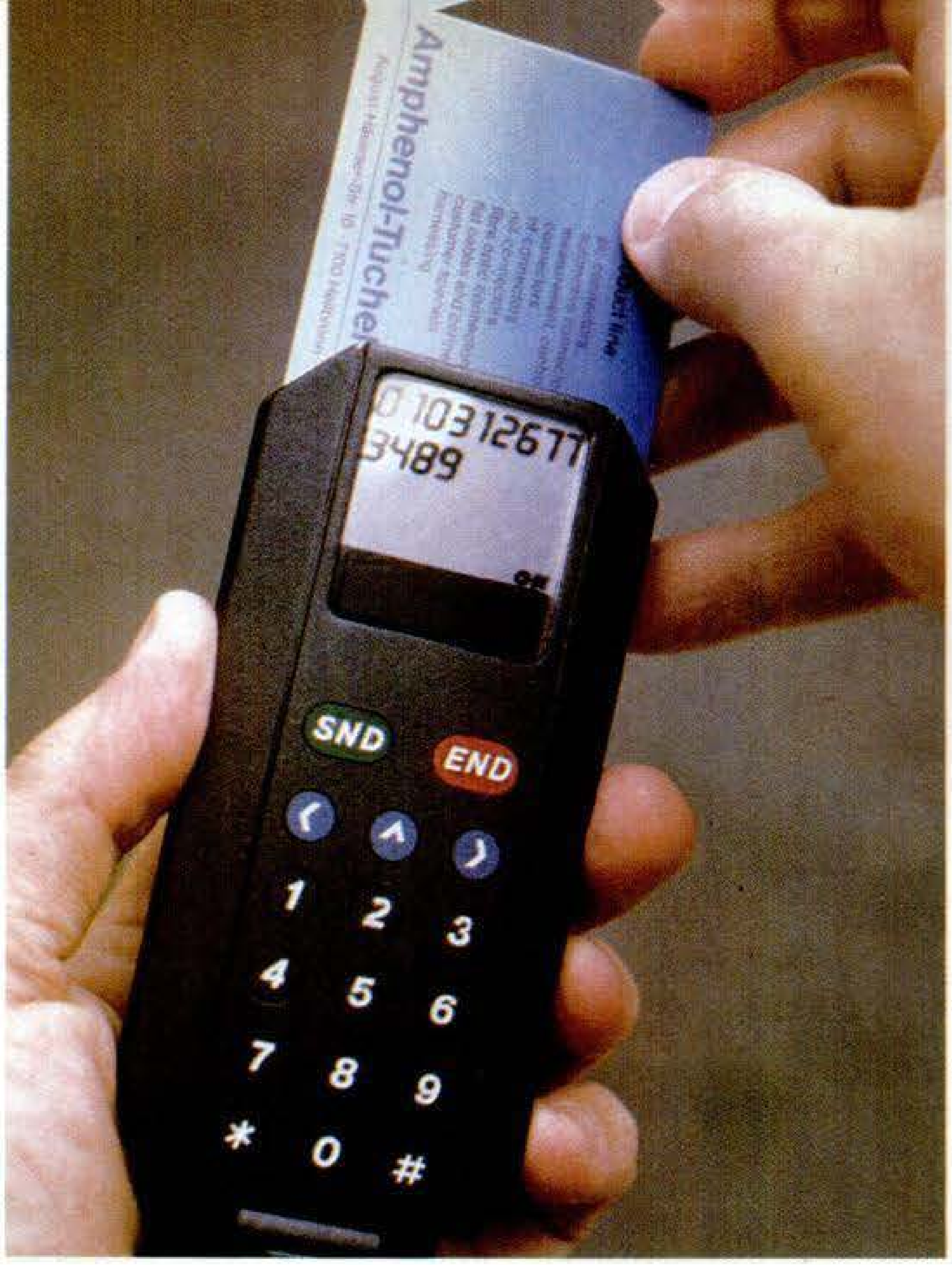
"Just before the coils are to be energized, a pneumatic motor starts the projectile spinning, for aerodynamic stability," Cowan continues. "Then we fire the coils with bursts of electricity, one after another, to get a traveling magnetic wave that moves faster with each burst of power. The entire process is computer-controlled, with optical sensors placed along the length of the launcher to determine the exact position and velocity of the projectile as it travels down the tube. That way we can fire each stage independently and sequentially."

In essence, the coils "hand off" the magnetic wave to each other. Picture an old-fashioned bucket brigade, with firemen passing buckets of water to one another down the line, each handoff occurring ever faster, and you'll get the concept. The projectile stays just ahead of the magnetic wave, riding it as a body surfer would an ocean wave.

"We now have a six-stage scale-model launcher, which fires a five-and-a-half-inch-diameter projectile that weighs five kilograms [11 pounds]," Cowan says. "We plan to build a launcher prototype that will have a full-size diameter of two and a half feet and full-mass capability of a metric ton. We will build enough stages, ten to twenty, to get to a speed of about 300 meters [984 feet] per second to show we know how to build the big coils. Then it will be just a matter of adding stages to get the speed up."

Key elements in this concept are banks of capacitors, which slowly store electrical energy then quickly release it. The capacitors make the launcher, with its sequential firing, possible. Strategic Defense Initiative research has resulted in significantly reducing the size and cost of capacitors. In 1985, for example, a capacitor bank that stores 1.4 kilowatt-hours of electrical energy occupied a volume of 300 cubic feet. Today, the equivalent capacitor has a volume of 28 cubic feet.

Engineering problems still loom for the Sandia launcher. Electronic payloads would be subjected to acceleration forces of 1,000 to 2,000 g's, so they will have to be shock-hardened. Also, at full scale there is a possibility that the projectile will scrape the flyway walls. The contact would cause sparks, which could generate plasma. The electrically charged gas could, in turn, interfere with the operation of the sensors and other electronic equipment, crippling the guns. Lastly, details concerning the projectile's aluminum substructure, which absorbs the load forces, and the carbon-phenolic heat shield, which protects the satellite as it speeds through the atmosphere, have yet to be worked out.



PERSONAL POCKET PHONES

Small radio-coverage cells—several blocks, or even a few building floors—coupled with advanced digital technology promise new go-anywhere telephones at reduced costs.

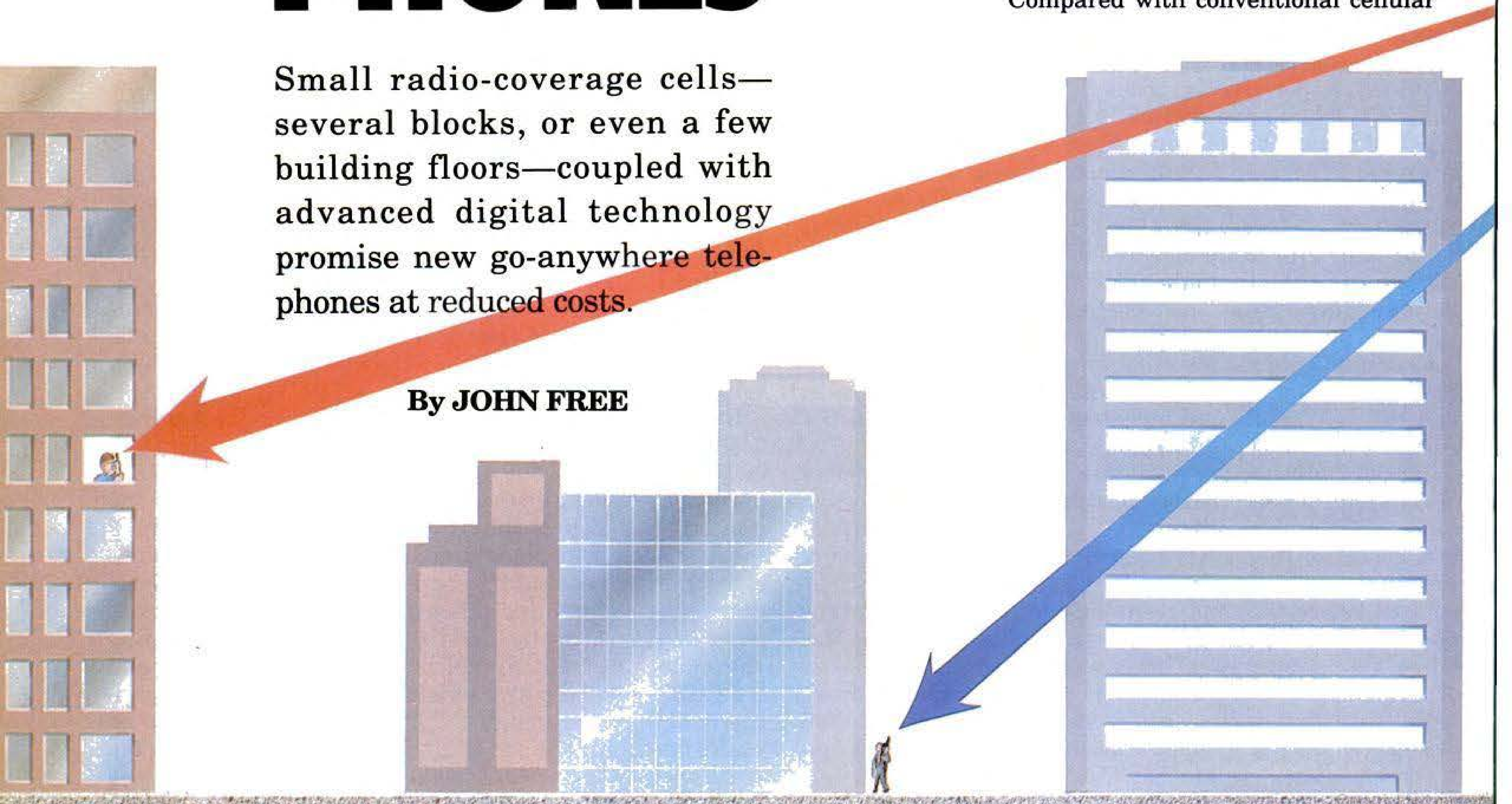
By JOHN FREE

You've just had a cellular telephone installed in your car. It's time for a test. As you drive to work, several attempts at calling the office fail. All the radio telephone channels are being used. Finally the call goes through. But one minute later a distant computer switches your call to the new cell region you've just entered. Too bad. Now that cell's channels are all busy. Your call is dropped.

Welcome to the frustrating world of mobile-portable telephones. With prices for take-along phones still falling—down to $299 for one Radio Shack model—cellular phones are being grabbed up like bars of soap from Russian store shelves. Although cellular phone systems are designed to handle lots of calls, they are being overwhelmed in large cities, especially during peak-use periods.

Help is on the way. Telecommunication companies are developing new wireless phone systems called personal communication networks (PCNs). They can use a sophisticated technology developed for the military that lets 20 or more callers share a slice of the radio spectrum simultaneously. This spread-spectrum technology can be used with low-cost phones that are small enough to fit in your shirt pocket. You'll see wrist-phone models eventually.

Unlike today's portables with limited battery life, PCN phones will let you talk—or send facsimile copies and computer data—most of the day. Compared with conventional cellular

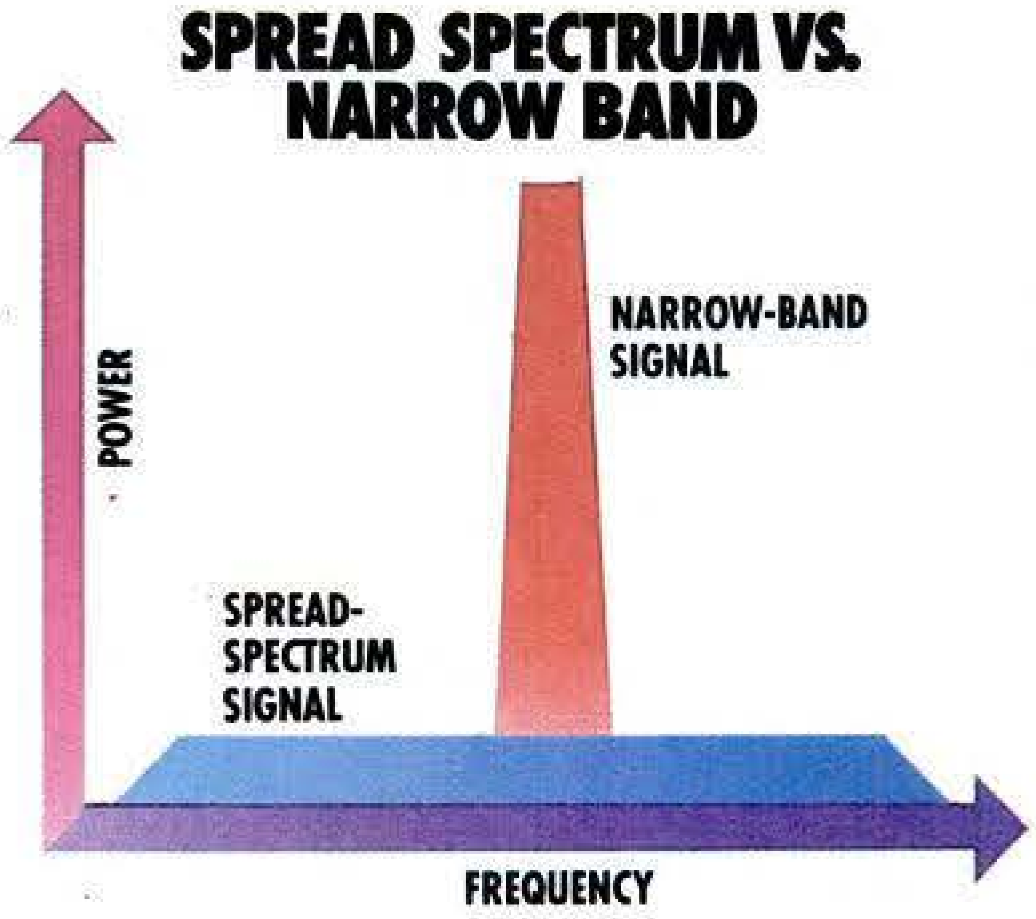


systems, your calls will be more resistant to interference and virtually impossible to eavesdrop on. Numerous other products can also use spread spectrum ["World Without Wires," April].

Ordinary cellular systems cover geographic areas with hundreds of frequencies, distributed between the cells to minimize interference. By repeating the use of these frequencies in nearby cells, more mobile and portable phones can operate at once. Cellular systems can expand the number of calls possible by shrinking cell sizes and adding more of them. But new cells are costly and mutual radio interference eventually limits their size. Because of this, cellular phone manufacturers recently set standards for a new digital system that can put three or more calls on a single radio channel ["Cellular Goes Digital," Jan.].

This technique, called time-division multiple access, converts continuous analog voice signals into a stream of on-off digits. These digital signals from several callers are assigned split-second time slots, then are strung together and compressed for transmission over one radio channel. Cellular receivers assemble bits from the proper time slot and convert them into speech.

Spread-spectrum for PCN cellular radios is digital too, but uses a technique called code-division multiple access: Clusters of data representing the sampled voices of many callers are electronically multiplied with a coded high-speed randomly generated waveform. The resulting signal then modulates a relatively wide radio channel, spreading the data over a range of frequencies. The receiver collects only packets of digits with the proper code, converting them into speech.

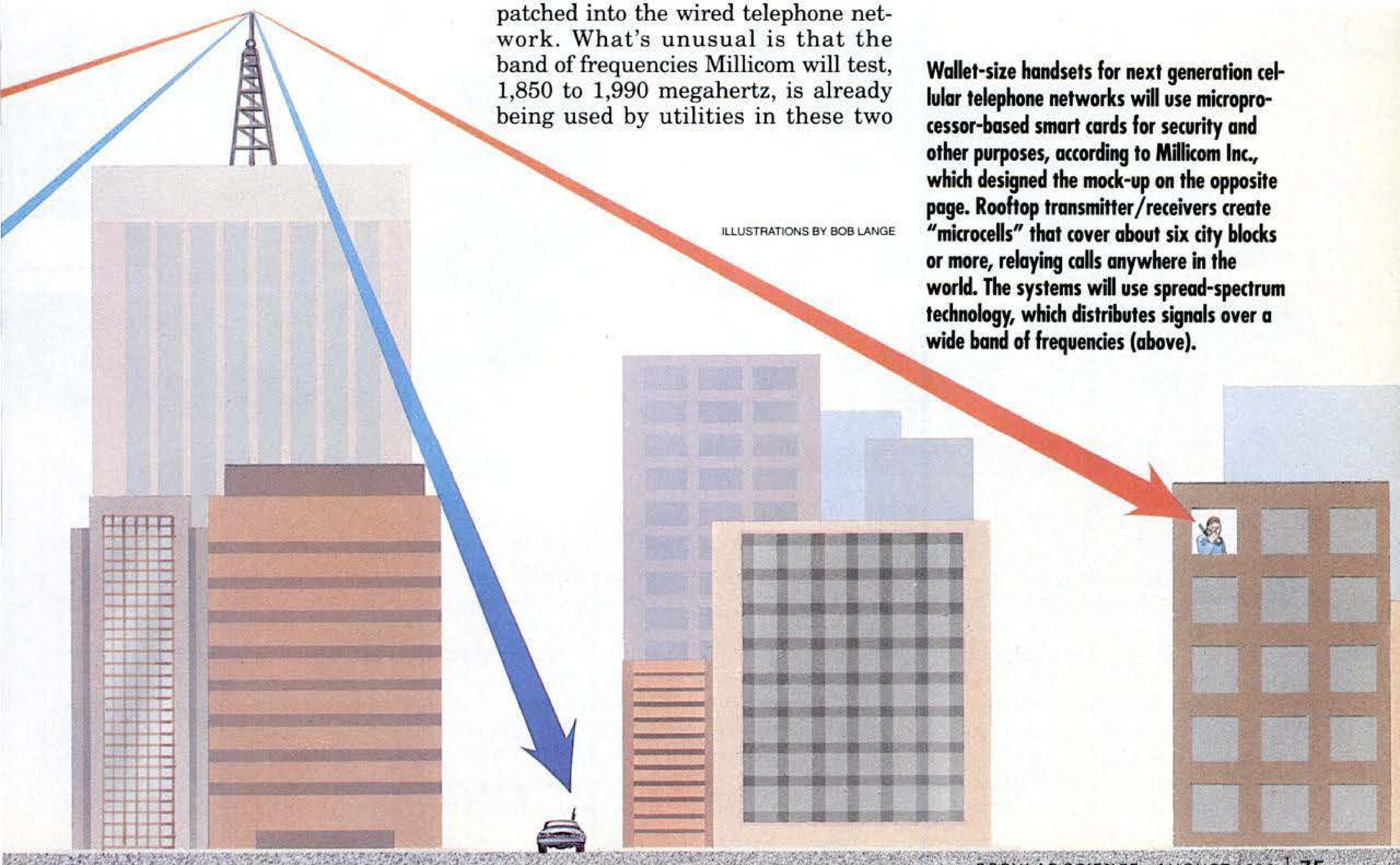


This spring the Federal Communications Commission licensed New York's Millicom Inc. to experiment with spread-spectrum systems. By 1992 Millicom plans to set up pilot PCN systems in Houston and Orlando, Fla. The networks will have 1,200-foot-diameter and larger cells, which are linked to a central switching station. Calls, of course, can be patched into the wired telephone network. What's unusual is that the band of frequencies Millicom will test, 1,850 to 1,990 megahertz, is already being used by utilities in these two cities for point-to-point transmission of data.

Won't the two systems interfere with each other? That's one question the test networks are likely to answer. "The way we have it designed," says Millicom consultant Dr. Donald Schilling, "the amount of power the point-to-point microwave user sees is maybe one-hundredth or one-thousandth of the total power we transmit." Typically, Millicom's ultra-compact PCN handsets will transmit at only one milliwatt. Calculations show PCN emissions will be small enough so that systems built into utility transmissions can compensate for them. Depending on the distance from the caller to the nearest PCN base station, power will be automatically adjusted from 100 microwatts up to 100 milliwatts.

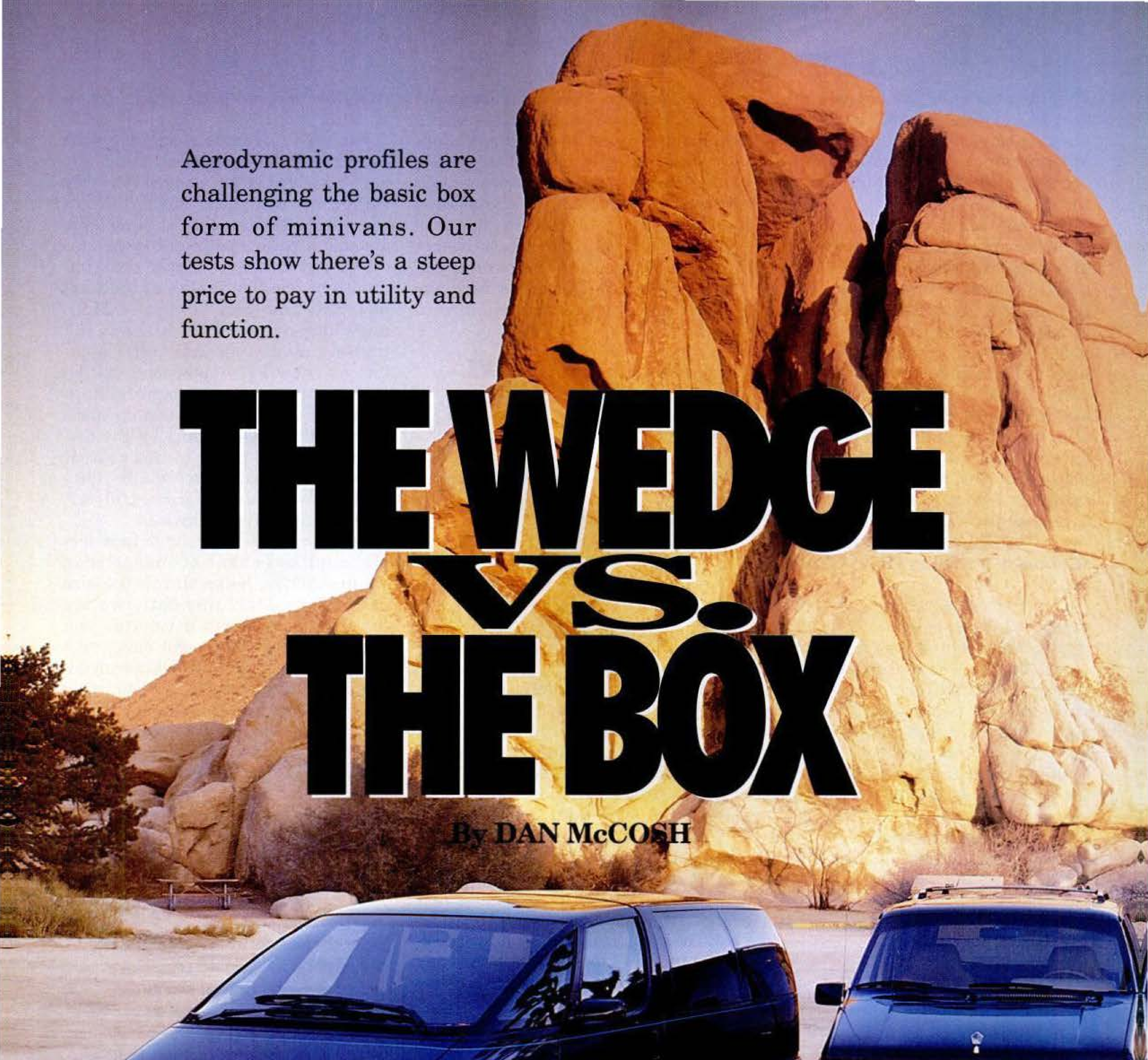
Such minuscule power output levels, similar to that of inexpensive walkie-talkies, helps shrink the size of handsets. Only tiny batteries are necessary. Millicom estimates you could talk more than eight hours on a battery charge. By contrast, a conventional cellular portable, transmitting at up to 0.6 watt, drains a small battery in about 30 minutes.

The operators of conventional cellular systems may also adapt some of their frequencies for spread spectrum. Qualcomm, Inc. in San Diego is one of the firms developing the necessary technology to aid them.



ILLUSTRATIONS BY BOB LANGE

Wallet-size handsets for next generation cellular telephone networks will use microprocessor-based smart cards for security and other purposes, according to Millicom Inc., which designed the mock-up on the opposite page. Rooftop transmitter/receivers create "microcells" that cover about six city blocks or more, relaying calls anywhere in the world. The systems will use spread-spectrum technology, which distributes signals over a wide band of frequencies (above).



Aerodynamic profiles are challenging the basic box form of minivans. Our tests show there's a steep price to pay in utility and function.

THE WEDGE VS. THE BOX

By DAN McCOSH

Auto designers would like us to believe that form follows function. But too often, it seems, form follows fantasy. Forty years ago the image of a P-38 fighter plane inspired the Cadillac tail fin. Today, aerodynamic concerns form a more logical basis for the streamlined noses of the newest minivans. But the main point appears to be simply a more modern look. Form thus adapts itself to function, and the minivan will never be the same.

This aero-profile is most apparent in General Motors' new generation of slant-nosed minivans, the Chevrolet Lumina and its Oldsmobile Silhouette and Pontiac Trans Sport siblings. These wedge-shaped vans were quickly followed by the Toyota Previa, which has a profile that matches GM's so closely you could almost superimpose one on the other and do a passable imitation of the opening to the old Alfred Hitchcock television series.

The domesticated minivan may seem an improbable venue for radical styling treatments, but today's van engineers clearly are taking more chances. Chevrolet's new

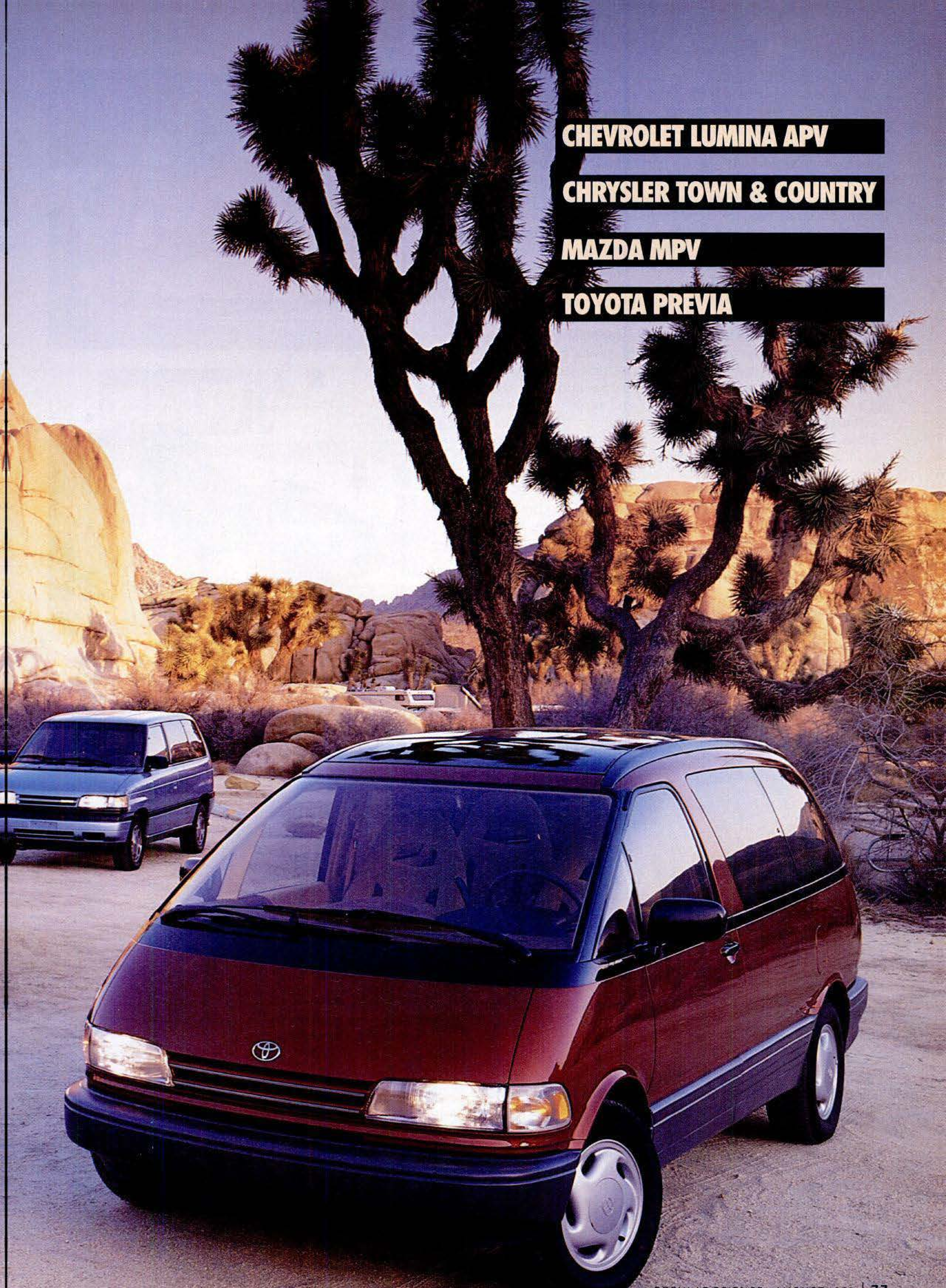
PHOTOS BY JOHN B. CARNETT

CHEVROLET LUMINA APV

CHRYSLER TOWN & COUNTRY

MAZDA MPV

TOYOTA PREVIA



Lumina APV, the Toyota Previa, the Chrysler Town & Country, and Mazda's MPV—the quartet that we tested—represent widely divergent approaches to the minivan theme. And the shape isn't the only thing that's different—the variations now include avant-garde body structures and oddball engine layouts. GM built its new trio of vans using a structural space frame and plastic skin ["GM's New-Technology Plastic Van," June '89], an unconventional construction technique that promises a ding-free and rust-free body. Toyota attempts a midships engine location for its van, a seeming impossibility, but manages to pull it off with some innovative design work.

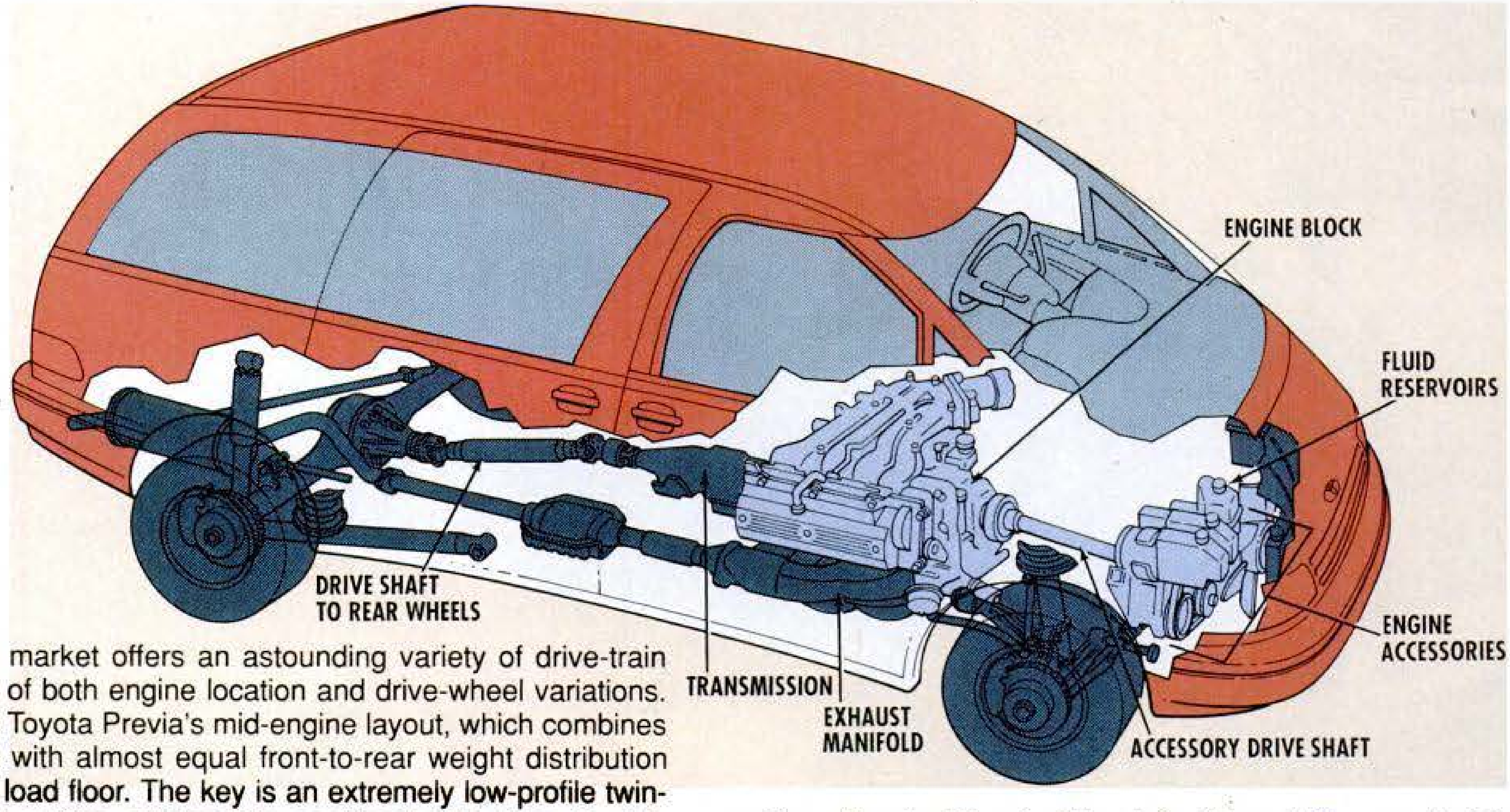
The wedge designs of both the Lumina and Previa carry the roof line to the bumper in one sweeping line—a simple, dramatic statement that demands some creative engineering to solve the problems inherent in the steeply slanted windshield. The problems, in fact, once were deemed so difficult by Chrysler and Ford that both rejected the single-plane front end in favor of a conventional windshield and short hood. But with the realization that minivans are mainly people movers and will spend their days in posher surroundings than a plumber's truck would, GM and Toyota pushed this generation of station wagon surrogates into a more stylish arena.

The dominant minivan configuration still is the functional box, best defined by Chrysler's minivans: front-wheel drive with a pugnacious front end, seven-passenger seating in two buckets and two benches, and subdued interior design. Options in Chrysler's basic minivan include a stretched wheelbase, a domestically built 3.3-liter V6, and an electronically controlled transmission. While there have been no fundamental changes for the Plymouth Voyager/Dodge Caravan in 1990, a Town & Country luxury-trimmed offering from Chrysler has been added to compete at the top of the market.

Chrysler had few serious challengers from overseas un-

When folded out of the way, the Toyota's third row seat tucks up conveniently to the side walls of the van (top). Parking the Chevrolet Lumina is tricky because it is so hard for the driver to judge where the hood ends.

FOUR UNDER THE FLOOR



RUSSELL VON SAUERS

Today's minivan market offers an astounding variety of drive-train choices in terms of both engine location and drive-wheel variations. To those add the Toyota Previa's mid-engine layout, which combines rear-wheel drive with almost equal front-to-rear weight distribution and a nearly flat load floor. The key is an extremely low-profile twin-cam four-cylinder engine, achieved by canting the block on its side at 15 degrees above horizontal. Top-to-bottom height is only 17.3 inches (see illustration). Power goes both ways: to the rear axle via the transmission and drive shaft, and forward through a 31-inch tubular accessory shaft to operate the cooling fan, air conditioner, power-steering pump, and alternator—all neatly tucked under a small hood.

Flip the driver's seat back, open the trap door, and you'll find an engine with a traditional oil-level dipstick and filler cap, but that's doing it the hard way. To keep oil at a constant level, the Previa has a remote reservoir up front that automatically sends lubricant to the engine as needed. When the sump's floating oil-level sensor falls to its minimum level, a pump mounted at the bottom of the auxiliary tank transfers just enough oil to the engine. If the front tank is allowed to go dry, a warning light on the instrument panel flashes to let you know it's time for a refill. *—Brian Nadel* til the introduction two years ago of the Mazda MPV, which combines an ingratiating level of carlike handling with some offbeat notions such as a hinged (rather than sliding) side door and rear-wheel drive.

Rear-wheel drive, up to now, also was favored by both General Motors and Ford, which based their Astro and Aerostar minivans on a rear-drive chassis developed primarily to provide an economical entry in the commercial-use van market. As it turned out, demand took a U-turn, and today both GM and Ford sell the bulk of their rear-drive minivans for people-hauling. The front-drive APV gets its basic transverse engine, front-wheel-drive layout from General Motors' A-car platform, establishing the basic dimensions and layout of the van. The APV's structure is significantly different, however. It's an expansion of the plastic-on-frame construction that was originally developed for the Pontiac Fiero, a steel space frame with molded plastic panels forming the exterior skin.

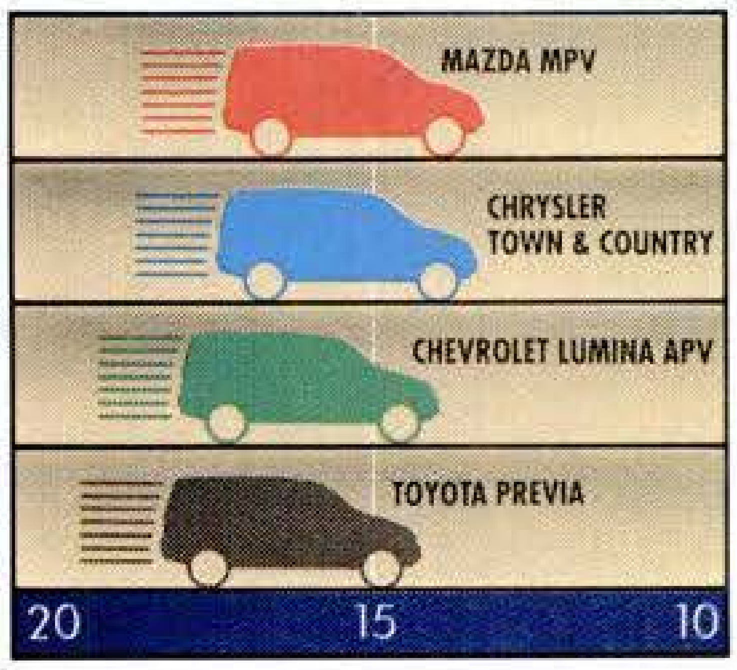
So far, most Japanese minivans have been based on rear-drive commercial vehicles originally tailored for narrow Tokyo streets. Mazda first made the break from this scheme, and now Toyota's new design for the Previa puts all that in the past tense, creating a longer and wider chassis in the American minivan idiom. It stands taller than the other vans in this group, too, and has a higher floor. The most significant change resulted from the decision to stick with a fore-and-aft rear-drive engine location, roughly between the front seats. Intrusion into the front seat area has been minimized by tipping the engine nearly on its side (see box, Four Under The Floor). The Previa engine location is one of those oddball ideas that can be made to work if you try hard enough, and Toyota did.

The problem with the engine layout is that it includes a 2.4-liter four-cylinder engine that is one of the smallest installed in any minivan, and there doesn't appear to be much room for additional cylinders. The engine churns out 138 horsepower at 5,000 rpm with the aid of a 16-valve cylinder head and fuel injection, but torque is only 154 pound-feet at a peaky 4,000 rpm. This compares with 150 hp and 185 lb.-ft. of torque for the Chrysler, the best in this class.

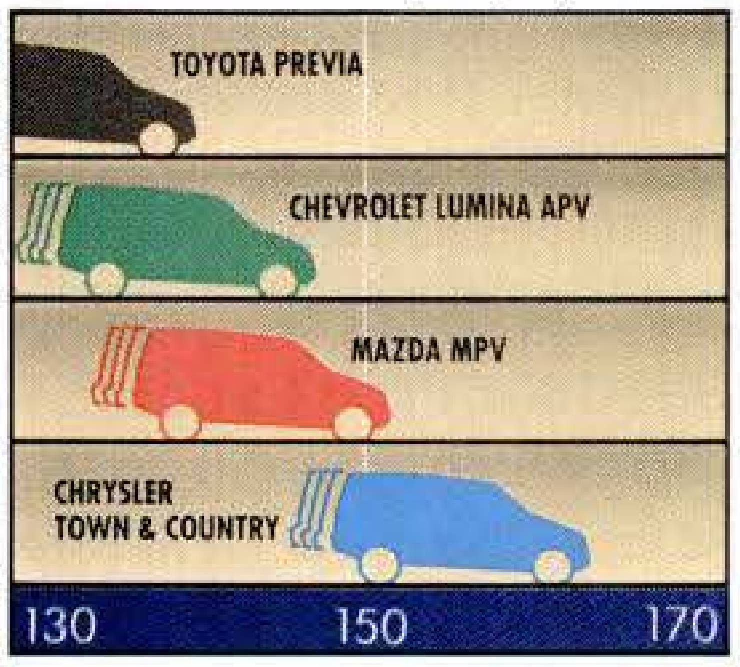
With a single occupant, the Previa managed only a stately 14.4 zero-to-sixty-mph time, slowest in the group, behind the 14.1 seconds of the Lumina, and nearly a second slower than the 13.5 seconds clocked by the first-place Mazda. The Lumina's V6 was ill-matched to its three-speed automatic, but its pulling power made it quickest from a standing stop to 30 mph. (A larger 3.8-liter V6 engine option with a four-speed automatic transmission is rumored for 1992.)

One argument in favor of a mid-engine configuration is improved front-to-rear weight distribution. Sharper handling should be the theoretical result, but on the skid pad the Previa showed no significant improvement over the front-drive Chevrolet APV and Chrysler Town & Country. In fact, the rear-drive Mazda was clearly superior to all three. On the lane-change and slalom the Toyota gained some ground, finishing only marginally behind the Mazda, but well ahead of the Chrysler and Chevrolet.

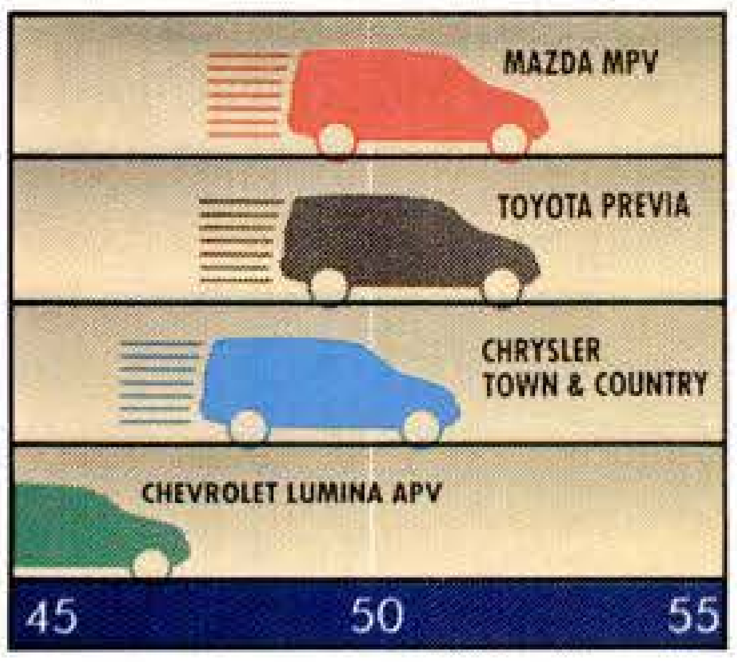
ACCELERATION 0–60 mph (sec.)



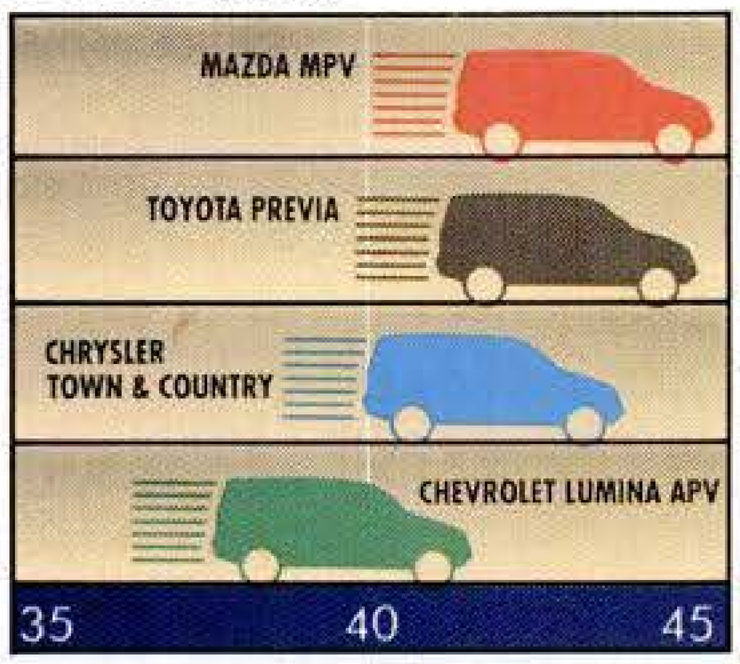
BRAKING 60–0 mph (ft.)



DOUBLE-LANE CHANGE (mph)



SLALOM (mph)



Our track-test results were substantiated by hundreds of miles on the highway. The Mazda MPV stood out with its overall quiet ride, precise steering, and predictable balance. A tight body structure, comfortable seats, and a functional interior quickly reinforced our previous judgment that the Mazda's strong point is road-worthy performance.

The Toyota likewise was more responsive than most vans, but the mid-engine layout contributed to an annoying fore-and-aft pitching. The Chrysler approached most highway bumps with a harshness that is probably its worst feature; it excels with steering that is predictable and tracks straight. The Lumina provided passengers the best road isolation, despite some grumbling over rough surfaces. But it is the Lumina that raises the question about how far a designer should go to create a pretty face.

From the driver's seat, the 19½ square feet of heat-reflecting glass slant forward until the glass seems to converge with the flat expanse on top of the instrument panel somewhere near the horizon. The nose of the car is several feet beyond that, out of sight, but not out of mind. The limitations of forward visibility made it tricky to negotiate some of our track tests. In a snowstorm, the narrow triangles formed by the side inserts in the windshield filled with snow, and forward visibility was cut to the swath carved out by the massive windshield wipers. In addition, side vision is restricted by the thick, rear-slanted B-pillars. Eventually, I got used to some of these quirks, but never grew fond of them.

It is easier to see out of the front of the Toyota van. Despite the similarities to the GM design, the more vertical rake of the Toyota windshield improved forward visibility substantially. But the forward-raking B-pillars—another styling detail—intruded into the door opening to the point that getting in and out was literally a headache. The Toyota has its own visual weak point, created when the rear seat is flipped to its storage position—hinged along the rear side of the cargo area, where it blinds the view through the rear side windows.

After several days of loading and unloading people with this group of vans, we reached the conclusion that the short center bench seat used by Chrysler and Mazda (and the base-level Lumina and Previa) makes a much more sensible arrangement for car-poolers. One alternative offered by the Lumina is a center row of three modular seats. The right side seat flips forward to provide access to the rear seat, and frankly, the move is awkward. You could also remove the center seat from the middle row and slide between them, but that's only a slight improvement. The Mazda's main drawback was a third seat that requires tools for removal and a high floor in the rear, which diminished its utility as a cargo carrier. Each manufacturer provides some flexibil-

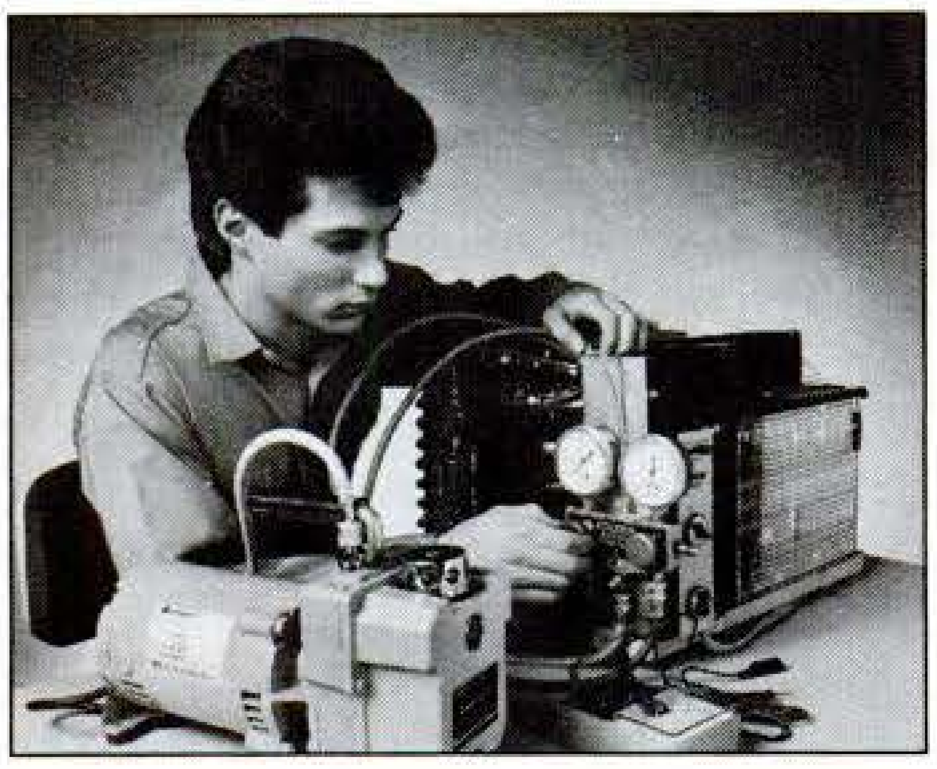
Get into your own business with NRI at-home training in Air Conditioning, Heating and Refrigeration.

Now NRI's home study course in Air Conditioning, Heating, and Refrigeration includes training in heat pumps and solar energy systems.

Prepare yourself for a whole new career in one of the fastest growing fields around. As energy needs continue to grow and energy sources become scarcer, the demand for skilled technicians will soar. NRI can get you started in this opportunity area, and you learn at home in your spare time, tailoring your training to your need with a choice of NRI's Basic or Master Courses.

Includes Professional Vacuum Pump and Tools

NRI training is practical training. Along with bite-size lessons in theory and practice, you get practical bench training. NRI's Master Course includes professional tools . . . a system analyzer, leak detector, tubing and joint tools, and more. Plus demonstration units that graphically bring principles to life for easy understanding. You even get a top-quality vacuum pump for trouble shooting experiments and use on the job.



Optional Postgraduate Training at York Institute

Graduates of the Master Course are eligible for a concentrated week of resident training at the famous York Institute at no extra charge for tuition or training materials. Here, you'll work on advanced industrial equipment under the guidance of expert instructors. *Only* NRI includes this opportunity.

Send for Free Catalog, No Salesman Will Call

Send the coupon today for NRI's free catalog showing all the equipment and describing the complete course. Over a million students have trained at home the NRI way. You can, too. If coupon has been removed, write to: NRI Schools, 4401 Connecticut Avenue, NW, Washington, DC 20008.

SEND COUPON TODAY FOR FREE NRI CATALOG!

NRI SCHOOLS
McGraw-Hill Continuing Education Center
4401 Connecticut Avenue, Washington, DC 20008

We'll give you tomorrow.

For Career courses approved under GI bill
☐ check for details

☑ **CHECK ONE FREE CATALOG ONLY**

- ☐ **Air Conditioning, Heating & Refrigeration**
- ☐ Building Construction
- ☐ Telephone Servicing
- ☐ Locksmithing & Electronic Security
- ☐ Small Engine Repair
- ☐ Computer Electronics
- ☐ Electronic Music Technology
- ☐ TV/Video/Audio Servicing
- ☐ Satellite Electronics
- ☐ Communications Electronics
- ☐ Bookkeeping and Accounting
- ☐ Travel Careers
- ☐ Basic Electronics
- ☐ Appliance Servicing
- ☐ Electrician
- ☐ Paralegal
- ☐ Automotive Servicing

Name (Please print) ____________ Age ____

Street ____________

City/State/Zip ____________

Accredited Member National Home Study Council

515-080

PROFESSIONAL QUALITY WEATHER STATION NOW AFFORDABLE ENOUGH FOR HOME USE!

The new WeatherPro weather station uses state-of-the-art technology to give you full monitoring capability at an incredibly low price. The WeatherPro includes a weather computer, remote precision wind direction vane, wind speed sensor, external temperature probe, mounting hardware and 40' of cable-**all for only $179!**

- WIND SPEED
- TEMPERATURE
- WIND DIRECTION
- TEMPERATURE HI/LO
- RAINFALL (OPTIONAL)*
- WIND GUST
- WIND CHILL
- TIME
- AUTO SCAN
- 1 YEAR WARRANTY
- 14-DAY MONEY-BACK GUARANTEE

DIGITAR WEATHERPRO
WEATHER STATION: ONLY $179!
ORDER TODAY:1-800-678-3669, PS
M-F 7AM-5:30 PM Pacific Time

*Automatic-emptying electronic rain gauge-$49.95
Add $5.00 for shipping. CA residents add sales tax.
Fax 1-415-732-9188 • M/C and VISA

DIGITAR®
3465 DIABLO AVE, HAYWARD, CA 94545

Practice wheel & rim safety, and we'll give you this solid bronze belt buckle.

Avoid needless accidents! Ask for the wheel & rim safety training kit provided jointly by The Goodyear Tire & Rubber Company and Motor Wheel Corporation. Post the charts in your garage. Train your service people in proper procedures. And we'll send you a free Think Safety belt buckle.

Write Wheel/Rim Safety Dept.,
1116 N. Washington, Lansing,
MI 48906-4841.

A safety education program sponsored jointly by

GOODYEAR
and
MOTOR WHEEL

ity in the seating configuration, so this is one detail potential buyers must match with needs.

Of the four vans, the Chrysler and Lumina shared the basic front-drive benefits of a flat floor capable of easily handling long loads. For stowing smaller parcels, I preferred the forward-folding rear seat of the Mazda to the flip-up split rear seat of the Toyota, both because of the aforementioned vision problem and because the shape of the load space created seems more usable. The lightweight pop-out rear seats in our Lumina are a unique feature that is seductive in its simplicity—at least until you discover you have to store the loose seats.

The Mazda's side-loading swinging door seems almost an anachronism compared with the sliding doors on the other three vans, although it is surprisingly wide and should be forever free of the rattles that plague sliding doors. At least it could be opened and closed easily, as could the smooth-operating Chrysler's. The side-door track on the Toyota easily clogged with grit, while the APV was so difficult to open and close that the latch handle on our test van was bent from the effort.

Ultimately, this became a test of how much practicality is worth giving up for an admittedly eye-catching exterior and interior design. I wouldn't forsake the lord-of-all-traffic sensation that comes from a conventional, upright windshield, and the ease of parking, entry and egress, and loading and unloading that are part of the basic architecture of the Chrysler minivan. But I would like to see a more modern interior and a cure for the thumpy ride.

The Mazda comes closest. It offers the greatest driving pleasure, combining a smooth V6 engine with precise handling.

Of the two rakish new entries, it comes to a choice between the head-bumping door opening of the Toyota and the problems with visibility in the APV. Both seem most at home on the highway, where it's easy to settle down and enjoy the view, and where aerodynamic benefits are maximized. PS

LONG DURATION, SHORT OVERLAP

Coming at the overlap between the first and second generations of the American minivan, this road test presents a mixture of old and new. In order of seniority:

The Chrysler minivan is the elder statesman that virtually created this market. At this point, though, the front-drive minivan often feels cumbersome, and the addition of leather trim to the Town & Country doesn't mask the fact that this aging veteran has lost the initiative.

In contrast, Mazda's MPV always feels light and maneuverable. Its power train provides power to the rear wheels smoothly and effortlessly, and the MPV is the most carlike minivan on the market today. On the down side, it tends to be claustrophobic with a full complement of passengers and luggage.

Chevrolet's Lumina APV takes the wedge look well past its logical conclusion into the arena of self-parody. From the driver's perspective, the sloping nose not only makes parking-lot maneuvers a chore, but puts a vast expanse of wasted space between the driver and the windshield. It is a competent front-drive vehicle, and modular seating makes for a quick change from people to cargo mover.

In many respects Toyota's Previa is the answer to a question that nobody asked. The unique mid-engine, under-the-floor power-train layout is technically interesting, but the four-cylinder power plant is lacking in low-end torque and transfers too much vibration to the seat of the driver's pants. The Previa's utilitarian interior is contradicted by an exterior that resembles an overinflated balloon.

If pressed to decide which mini-mover has the right mix of ingredients, I'd rather cook one up from scratch, using the following recipe: Start with the Previa's space-efficient layout, add to it the Chrysler's ease of entry, sprinkle in the Lumina's eclectic looks and pull-out seats, and top it off with the MPV's power train and handling.—*B. N.*

POPULAR SCIENCE TEST RESULTS

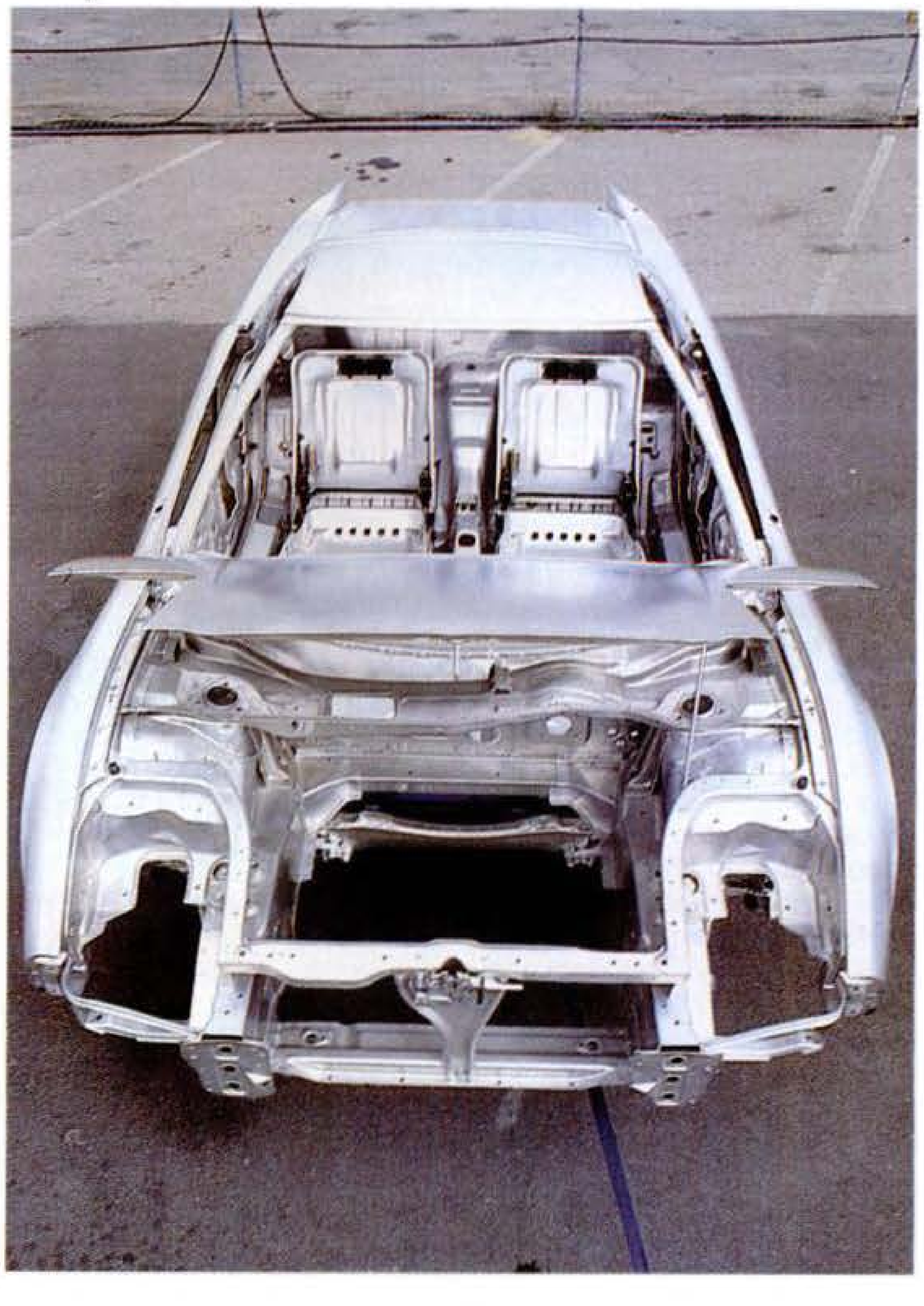
	Chevrolet Lumina APV	Chrysler Town & Country	Mazda MPV	Toyota Previa
ACCELERATION and HANDLING				
0-30 mph (sec.)	4.1	4.8	4.5	4.7
0-60 mph (sec.)	14.1	13.6	13.5	14.4
30-50 mph (sec.)	6.4	6.9	6.4	6.1
50-70 mph (sec.)	10.8	8.8	9.4	10.1
Double-lane change (mph)	47.4	51.2	52.4	52.3
Slalom (mph)	41.5	43.5	44.8	44.5
Road-holding (g)	0.67	0.66	0.70	0.67
BRAKES				
60-0 mph cold (ft.)	148	182	151	148
60-0 mph warm (ft.)	147	162	151	140
60-0 mph hot (ft.)	157	175	153	153
INTERIOR NOISE				
Idle (dBA)	46	45	46	45
60 mph (dBA)	72	74	70	70
0 to 60 mph (dBA)	76	79	76	80
SPECIFICATIONS				
Engine	3.1L V6	3.3L V6	3.0L V6	2.4L I4
Valve train	PR 2 valves/cyl.	PR 2 valves/cyl.	SOHC 3 valves/cyl.	DOHC 4 valves/cyl.
Power (hp) @ rpm	120 @ 4,200	150 @ 5,000	150 @ 5,000	138 @ 5,000
Torque (lb.-ft.) @ rpm	175 @ 2,200	185 @ 3,600	165 @ 4,000	154 @ 4,000
Compression ratio	8.5:1	8.9:1	8.5:1	9.3:1
Transmission	3-speed automatic	4-speed automatic	4-speed automatic	4-speed automatic
Final drive ratio	3.18:1	2.36:1	3.91:1	4.30:1
CHASSIS				
Front suspension	Independent, MacPherson strut, coil spring anti-roll bar	Independent, MacPherson strut, coil spring, anti-roll bar	Independent, MacPherson strut, coil spring, anti-roll bar	Independent, MacPherson strut coil spring,
Rear suspension	Torsion beam, trailing arm, control arm, coil spring	Beam axle, parallel leaf spring	Rigid axle, 4 trailing links Panhard rod, anti-roll bar	Rigid axle, Panhard rod, anti-roll bar, coil spring
Steering gear	Rack-and-pinion	Rack-and-pinion	Rack-and-pinion	Rack-and-pinion
Turning circle (ft.)	42.5	43.0	36.1	37.4
Brakes	Disc, drum	Disc, drum	Disc, drum	Disc, disc
EPA MILEAGE				
City	18	18	18	18
Highway	23	24	23	23
DIMENSIONS				
Wheelbase (in.)	109.8	119.1	110.4	112.8
Length (in.)	194.2	191.4	175.8	187.0
Width (in.)	73.9	72.0	71.9	70.9
Height (in.)	65.2	64.8	68.1	68.7
Curb weight (lbs.)/distribution (% front: rear)	3,495/60:40	3,817/56:44	3,146/60:40	3,475/51:49
Fuel tank (gal.)	20	20	19.6	20
PRICES, PARTS AND SERVICE				
Base price	$15,745	$25,000	$16,394	$18,698
Price as tested	$17,595	$25,103	$20,118	$22,268
Major options (over $100)	Preferred option group $910; seven-person seating $425; six-way power seat $270	California emission-control package $103	Power window package $1,645; A/C $1,497; towing package $498	Moonroof $1,370; ABS $1,130, alloy wheels $380
SPARE-PARTS COST				
Brake pads, front	$108	$ 99	$ 91	$ 66
Brake pads, rear	108	71	79	31
Front shock/strut insert (each)	75	58	101	142
Front fender	123	184	196	272
Alternator	136	259	136	532
Fuel pump	54	120	272	314
Ignition module	65	345	217	231
Grille	10	92	130	54
Front bumper	246	230	346	204
Windshield	514	225	298	n.a.
Taillight lens	54	75	29	133
PS SERVICEABILITY				
Total of 12 items (maximum of 60 points)	38	40	36	34
Best feature	Oil, water fill-up	Overall access	Fuses	Belts
Worst feature	Hoses	Spare tire	Spark plugs	Spark plugs

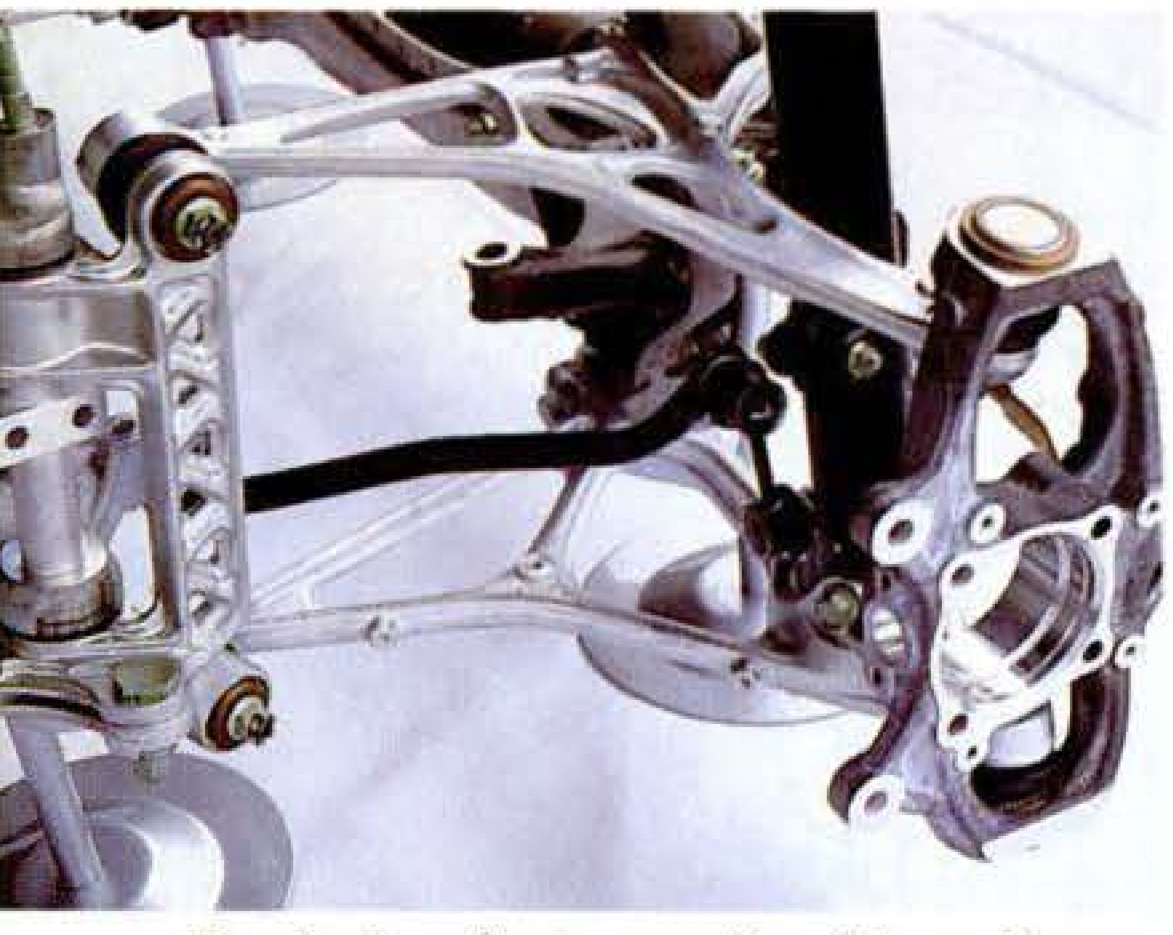
* not available

MATERIAL WEALTH

The new Acura NSX sports car is not only rich in light alloy metals, it also has the mettle to take on the world's exotics.

By DAN McCOSH





The aluminum front suspension with compliance pivot (above) and body (right) make for a light NSX. The completed car (far right) uses every pound to its utmost for agile handling.

PHOTOS BY JOHN B. CARNETT

Doesn't it seem unthinkable that Honda, champion of Formula One racing and giant of automotive technology, has not a single showcase for its most advanced hardware. Sure, bits and pieces show up in the Acura Legend luxury sedan and sport motorcycles, but the best innovations from the research and development department all too often seem buried deep within mainstream Accords.

With the arrival of the mid-engine NSX two-seater (to be sold under the Acura nameplate), that is no longer the case ["Automotive Newsfront," May '89]. The new two-seater, at $55,000 to $60,000, is a direct assault on the market segment now occupied by Porsche's Carrera models and the Ferrari 348. But the approach is distinctly Honda: The NSX bristles with leading-edge technology. All of it applied for functional value rather than the need for good advertising copy.

From the sports car's aluminum suspension arms to the titanium connecting rods and spot-welded aluminum skin, the designers and engineers had one goal: take what they learned from Formula One and apply it to a low-volume production sports car. The single-mindedness of this task can be seen by how they answer pointed questions about their car.

Why does it have a V6 rather than a V8? "Too much weight."

Why not four-wheel drive? "Too much weight."

Why a transverse rather than longitudinal layout? "It's lighter."

Why the electric power steering? "It's lighter yet."

You get the idea. By using almost as much aluminum as a dirigible, the NSX car weighs in at a tad over 3,000 pounds (3,010 pounds for the manual transmission version, 3,098 pounds for the four-speed automatic).

The point of the exercise is not so much the reduction of weight but where it's distributed. With 58 percent of the car's mass on the rear axle, the NSX is more in the Porsche 911 mode than most modern sports cars. This weight bias gives the rear tires extra bite, favoring braking and acceleration. Concentrating the weight midships makes for a quick-turning, agile chassis, but could also yield a car that has the directional stability of a hockey puck. Not in this case—the NSX is a car of pleasant surprises.

My first surprise came in the tight turns of California's Laguna Seca race track. The NSX attacked the circuit with the force of an open-wheel race car. (Honda claims grip in excess of one g.) More impressive was the car's level of stability: It seemed to defy any effort to upset it—including heavy braking and stomping on the accelerator in a corner.

The next day, on California's Pacific Coast Highway, the NSX maintained its race-track balance, even when a spot of rough asphalt marred the apex of a corner. The steering wheel seemed to be equipped with a shock absorber that filtered out harsh jolts, but let through a steady flow of sensation concerning where the wheels were pointed.

Such overall harmony in a chassis is achieved by extreme body stiffness, trimming ounces where they count, and a device in the front suspension that Honda calls a compliance pivot. This forged-aluminum trusslike member is used as the mounting point for the front pivots of both the upper and lower control arms. Because the compliance pivot ties the upper and lower control arms together, when the wheel hits a bump both arms move in unison and the alignment settings remain constant.

The skeleton of the car is based on several complex extruded-aluminum parts, including tubular sections located along the outside edge of the floor pan and along the edge of the

[Continued on page 89]

New fitness prescription for the '90s.

Add strength to your life.

Looking, feeling and being the best you can be.

NordicTrack has just introduced the Nordic Fitness Chair, a revolutionary concept that allows you to add strength training to your exercise program, and helps you achieve Balanced Fitness — the new fitness standard for the '90s.

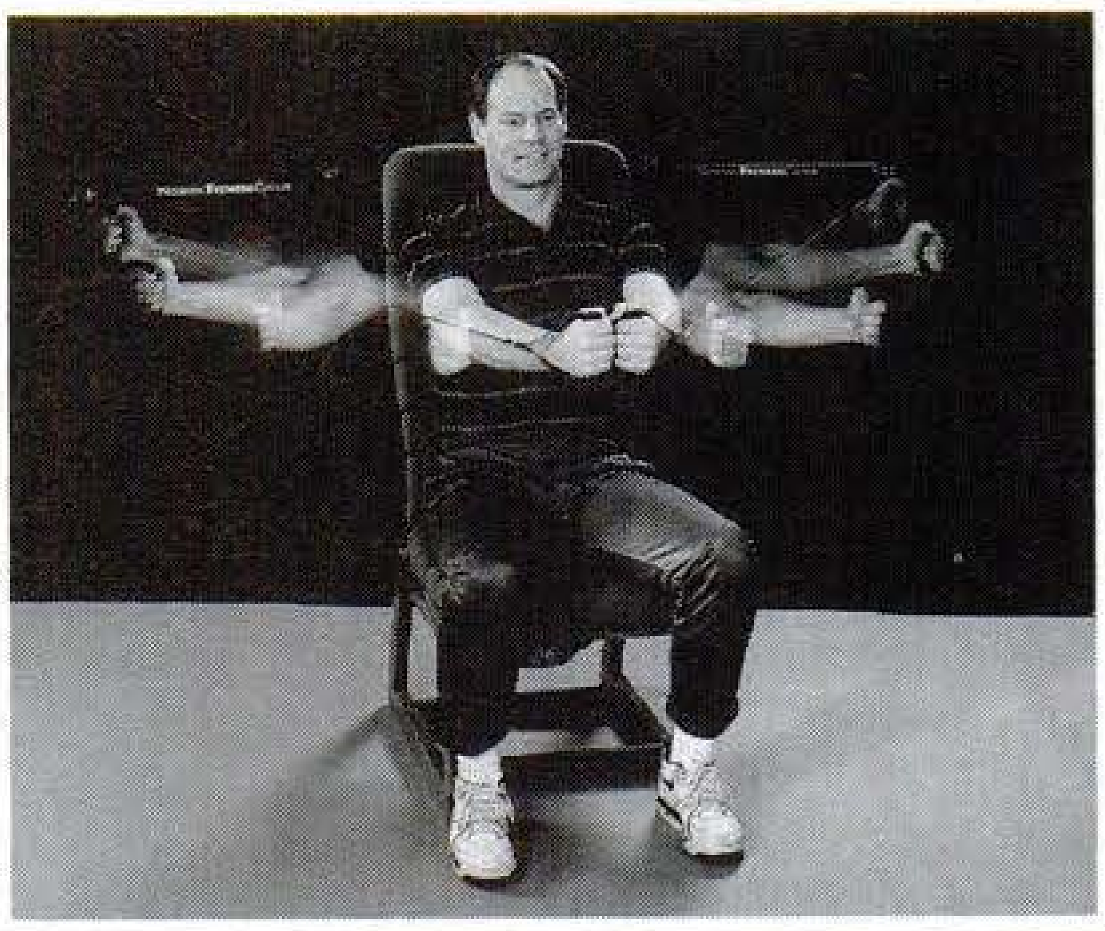
The Nordic Fitness Chair will change the way you look, and the way you think about fitness.

You work against isokinetic resistance to tone, strengthen and condition the muscles in your upper body. The Nordic Fitness Chair enriches your life by allowing you to develop your muscle coordination and control plus improved personal performance.

6 exercises. 3 times a week. That's all it takes.

The Nordic Fitness Chair's "Basic 6" workout takes only minutes a day, 3 times a week, so it will fit into even the busiest schedule.

Balanced Fitness is within easy reach.
Call 1-800-848-7786.



A HEALTH-CLUB WORKOUT IN THE COMFORT OF THE NORDIC FITNESS CHAIR.

NORDICFITNESSCHAIR™
from NordicTrack

Send for Free Brochure & Video

Call Toll Free in U.S. and Canada
1-800-848-7786

☐ Please send me a free brochure
☐ Also a free video tape

Name ____________________
Street ____________________
City ____________ State ______ Zip ______
Phone ( ) ____________________

NordicTrack, 141C Jonathan Blvd. N., Chaska, MN 55318
894H0 A CML Company

Assembly Power!

Heath provides an alternative for computer buyers who want to do more than just plug in a ready-made computer. Heath computer kits offer superior performance - and the satisfaction and pride of building a high-power laptop or desktop computer yourself.

Our expert team of computer sales consultants will give you a special price that's sure to fit your budget. Simply call 1-800-753-5454 and ask about any of these unbeatable systems:

- HS-3286 SupersPort 386 SX laptop
- HS-2862 12 MHz 80286 laptop
- HS-3629 32-bit, 25 MHz 80386 desktop

Heath
1-800-753-5454
(M-F, 8:00 a.m. - 4:30 p.m., EST)

THE NEW!

Weed Wizard®

*the amazing new solution to **rotary trimmer** line problems*

- No more trouble with trimmer line — **never buy line again!**
- Easy to install on **your** gas trimmer.
- Cuts through tough weeds, briars and grass.
- Keeps **your** rotary trimmer in business.
- **Guaranteed** to save you time!

ONLY $21.95

TO ORDER CALL TODAY
1-800-262-5122
(Call for dealership inquiry)

( ) VISA ( ) M/C # ____________________ Exp. Date ________
( ) Check enclosed for $21.95 plus $3.00 postage and handling. PS890

Your Trimmer Make ____________ Model # ____________
Name ____________ Phone ( )
Street ____________________
City ____________ State ______ Zip ______

Send to: **WEED WIZARD, INC.**, P.O. Box 275, Dahlonega, Georgia 30533

BREAK AWAY NOW!

Earn up to $75,000 a Year in Windshield and Plate Glass Repair!

- Big profits – good times or bad!
- Huge demand and growing!
- Part-time or full time.
- Great opportunity for men or women!
- Insurance companies, fleet owners pay top dollar regularly!
- Quick-learn, professional training.
- Free, on-going support/low-cost start-up.

Break away to a professional, respected business and BIG INCOME!

Call toll-free **1-800-321-2597** (US and Canada) to order your VIDEO and **FREE** report. Or write:

Act today — Send for Video Demo Now!

Glas-Weld Systems, inc.
Advanced Technology in Glass Repair
20578 Empire Blvd., Dept. C8
Bend, OR 97701
S.M.

CLEAN AIR PAINTS

New laws are forcing manufacturers to produce paint formulations that pollute less. Here's a look at these environmentally friendly finishes and what you can expect of them.

By TIMOTHY O. BAKKE

JOHN B. CARNETT

New York-based architect Mary Anderson knows her paint, or at least she thought she did.

"I had always specified solvent-based alkyd paint because of the exceptional sheen and smoothness of its finish," she told me. "It is also extremely hard and durable, especially important on high-wear interior surfaces. Nothing could compare with it."

But then something changed. New air-pollution controls went into effect in parts of New York last year—and in New Jersey this year—and they affected the paint on which Anderson had been relying.

"Starting last year, I began to hear complaints from painting contractors that the paint I was specifying was hard to apply and took too long to dry," Anderson told me. "When I tried using some new alkyd semi-gloss on a wall myself, I found that, indeed, the paint was not as easy to roll out as it used to be. The skim-coated plaster wall I was painting with a fine roller had been worked over and prepped well, so I should have been getting the best finish possible. Instead, no matter what I did, I ended up with an orange-peel-textured surface. And it took three or four days to dry. I was disappointed and confused."

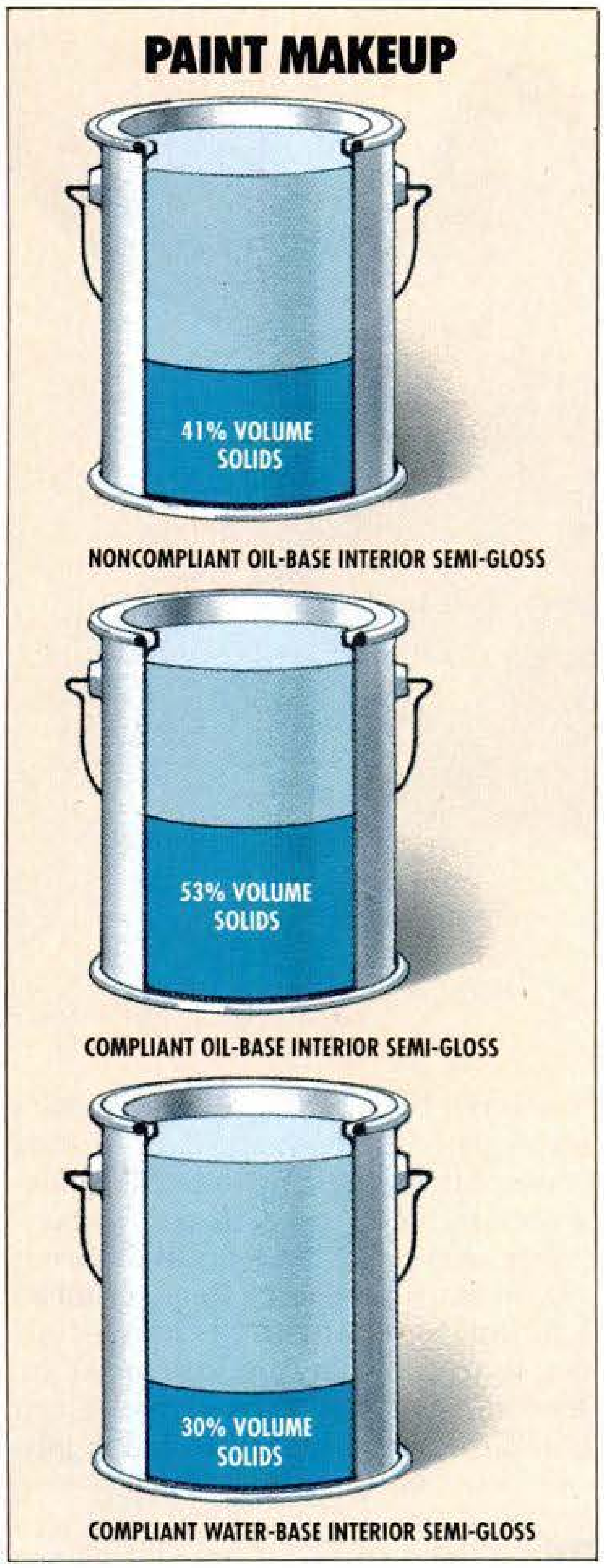
Anderson is not alone. The entire architectural coatings industry is reeling because of legislation across the country that restricts the emission levels of paint and other finishes. Most latex paints—interior flats and semi-glosses as well as exterior house and trim paint—are not affected; they are formulated in a water base and thus have low emissions. Most oil-based finishes *are* affected, however. To cope with the new regulations, manufacturers are reformulating these finishes, withdrawing some from the market, and coming up with new water-base technology to take their place.

The alkyd products that result are different from their predecessors in almost every way. They are more benign to the environment, but they also have greatly altered application requirements and performance characteristics—and generally higher prices. All this leaves painting contractors and homeowners in many areas in a quandary. Either they can't find familiar products on store shelves or they are faced with finishes that don't behave at all like the products they are used to. Depending on the kind of paint you intend to use, your future paint jobs may never be the same.

Emissions from oil-based finishes are called volatile organic compounds (VOCs). They come mostly from solvent chemicals—hydrocarbons like toluene, xylene, and naphtha—that are given off during application and curing.

"The VOCs combine with other hydrocarbons in the atmosphere and react photochemically with oxides of nitrogen to form lower atmospheric ozone," says Tom Graves, director of federal affairs for the National Paint and Coatings Association (NPCA). Lower atmospheric ozone is a potent pollutant that contributes to smog. It is not to be confused with stratospheric ozone, which shields Earth from the sun's ultraviolet radiation.

"There are one hundred or so areas of the country that don't meet air-quality standards for ozone under the current Clean Air Act," Graves points out. As a result, legislation to limit VOC emissions is being enacted across the country, albeit in a piecemeal fashion—in some cases differing from county to county. Parts of Arizona, California, Texas, and New York al-


PAINT MAKEUP
41% VOLUME SOLIDS
NONCOMPLIANT OIL-BASE INTERIOR SEMI-GLOSS
53% VOLUME SOLIDS
COMPLIANT OIL-BASE INTERIOR SEMI-GLOSS
30% VOLUME SOLIDS
COMPLIANT WATER-BASE INTERIOR SEMI-GLOSS

ready have laws on the books. New Jersey has passed statewide regulations. And state and local restrictions are being considered in Illinois, Indiana, Maryland, Massachusetts, and Wisconsin. This fragmentation plays havoc with the formulation and distribution of paint. Consequently the NPCA is recommending a federal regulation—based on the strict California Air Resources Board rules limiting emissions in flat and non-flat architectural coatings, for example, to 250 grams per liter—as an amendment to the new Clean Air Act expected to be passed later this year. Currently, many unrestricted alkyd coatings routinely exceed 400 grams per liter.

How are manufacturers complying with the regulations? To understand the answer, you first need to know what goes into these finishes. All contain some solid materials and some solvent; the ratio depends on the kind of finish. A traditional alkyd paint, for example, is somewhere around 60 percent liquid to 40 percent solid. The liquid is generally made up of linseed oil and volatile solvents, which help the paint spread and dry properly; the solid materials comprise pigments, alkyd resins that act as binders, and other additives. Conventional stains are about 80 percent solvent, while sealers are 90 to 95 percent solvent.

"To keep alkyd paints on the shelves, manufacturers are essentially reducing the amount of solvent, which increases the proportion of solids," Carroll Bennett, architectural market manager for Sherwin-Williams told me. "The paint therefore becomes somewhat thicker, so it may become harder to apply. It also goes on in a thicker film, which is good—and bad. It's good because the thick film may give you extra protection; but drying time is extended, from about forty-eight hours to ninety-six hours."

Also, durability is reduced. To maintain an acceptable viscosity in the higher-solids product, formulators changed the structure of the alkyd molecule. The alkyds' role is critical: These are the molecules that polymerize to form the paint film. Normally, alkyds are large long-chained polymer molecules that gain strength by forming chemical bonds with other large molecules, like long strands of spaghetti that intertwine. The newer alkyds are shorter-chained, like smaller strands of spaghetti. They flow more easily, but they aren't as strong.

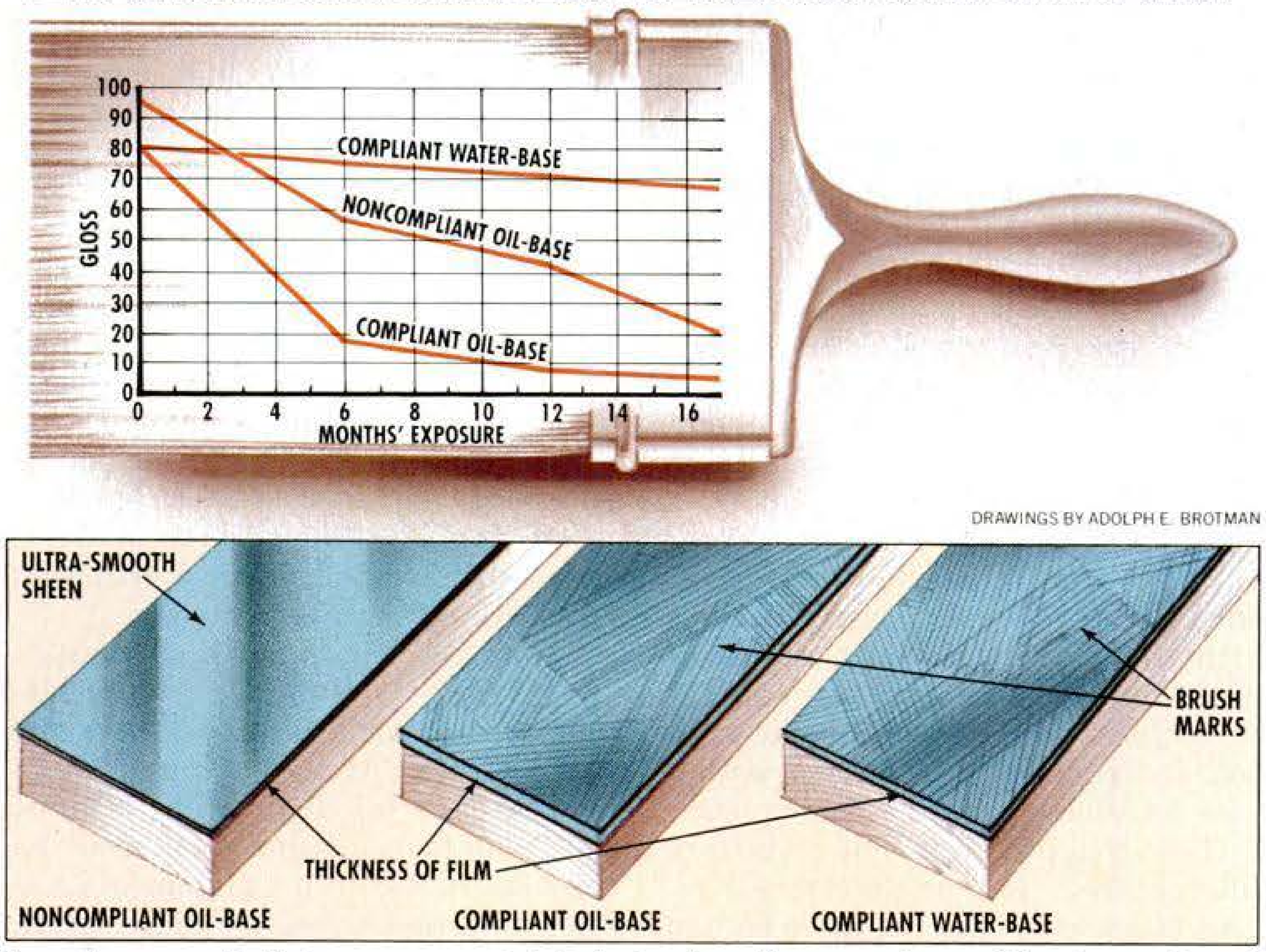
"With some kinds of finishes, such as interior flat wall paint, interior semi-gloss, and exterior house and trim paint, there have long been high-quality latex alternatives to alkyds, so a maker may or may not reformulate—it might simply withdraw the oil paint from the market," Bennett continued. "Since most consumers use latex anyway, they won't miss the oil paint." In other categories, like gloss enamels, outdoor varnishes, and most industrial coatings, however, there were no acceptable alternatives that complied with the new laws. Thus manufacturers have been *forced* to develop new formulations.

Oil-based gloss enamel, the primary attribute of which has always been its glasslike finish, is especially hard hit. Currently there is no substitute—either a reformulated alkyd or a latex—that exhibits its qualities of smoothness and high initial gloss, although acrylic enamels are coming close and actually *retain* their sheen longer (see drawings and graph).

The solids contents are being increased in clear finishes and stains as well. "Clear coatings have typically been formulated in the thirty-eight-to-forty-five-percent solids range. With the new regulations you're in the sixty-three-to-sixty-five-percent range," says Barry Oppenheim, technical manager for McCloskey's, a division of Valspar (see box, New Clear Finishes). "In stains, people are used to seeing very thin products, in the fifteen-to-twenty-eight-percent solids range, maximum. They have a viscosity pretty much like water. The new stains have to be in the sixty-five-to-seventy-percent solids range."

The new-formulation stains are so

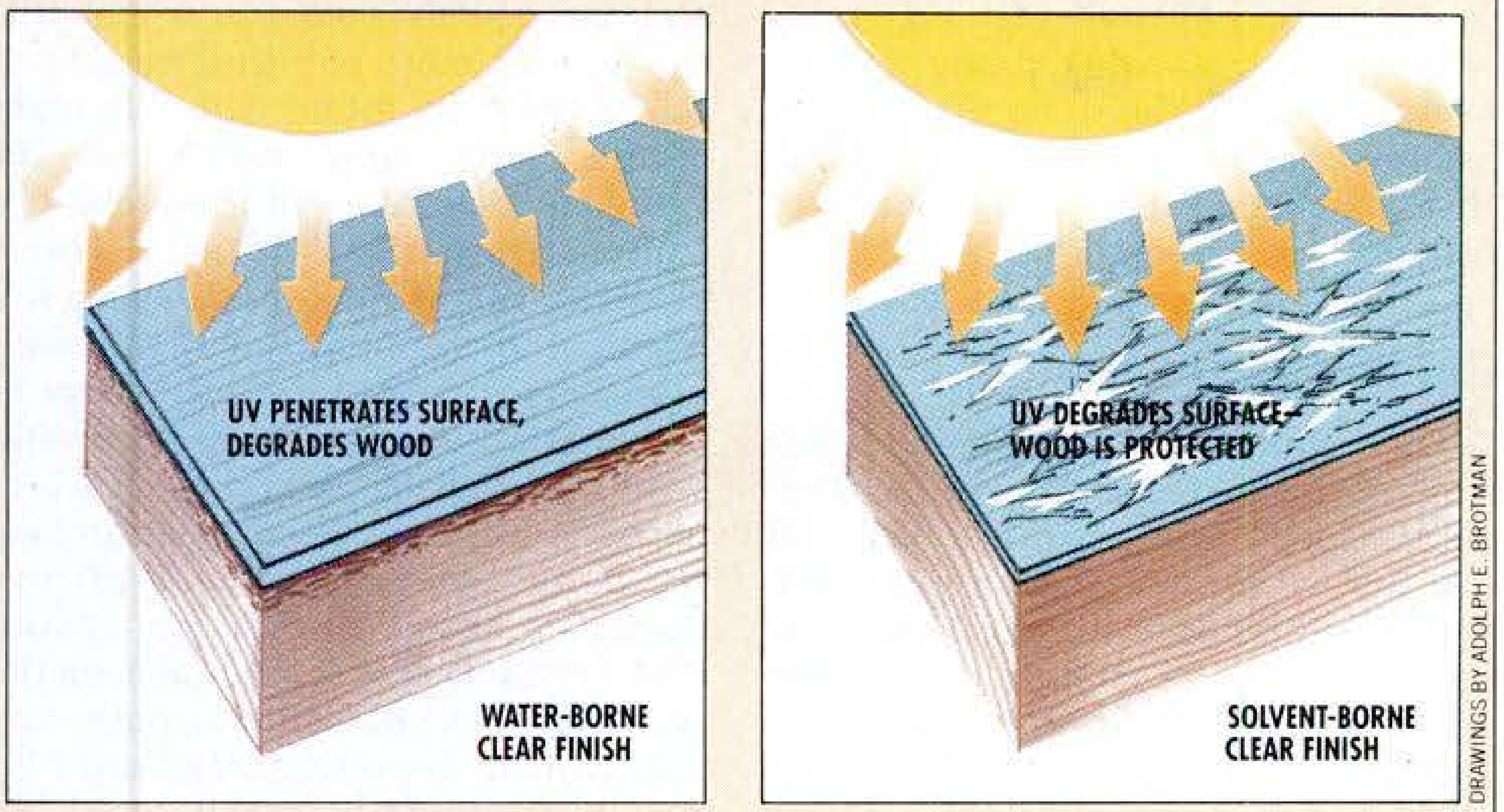
EXTERIOR GLOSS ENAMELS: THE OLD OUTSHINES THE NEW



DRAWINGS BY ADOLPH E. BROTMAN

New gloss enamels don't measure up in initial gloss (graph) or smoothness (above) to traditional products. Latex does, however, surpass its alkyd cousins in gloss retention (see graph).

NEW CLEAR FINISHES: PROMISES, PROBLEMS


UV PENETRATES SURFACE, DEGRADES WOOD
WATER-BORNE CLEAR FINISH
UV DEGRADES SURFACE—WOOD IS PROTECTED
SOLVENT-BORNE CLEAR FINISH

DRAWINGS BY ADOLPH E. BROTMAN

Most formulators of clear finishes are complying with VOC regulations by increasing the proportion of solids rather than by developing water-based formulations. Why? 1) Water-soluble resins used in clear finishes are transparent to ultraviolet radiation, allowing the UV radiation to degrade the wood below (drawings). Conventional solvent-based resins absorb UV radiation and are "self-sacrificing." The finish itself is degraded by UV radiation, protecting the wood. 2) Water-borne acrylic polymers are not hard enough ["Water-Based Varnish," Jan. '89]. Catalysts make the product stronger, but difficult to work with.

Though the first problem has yet to be solved, Flecto, with its Varathane Diamond Finish, BonaKemi USA (Woodline Waterborne Urethane), and Pratt & Lambert's Fabulon Division (Crystal Finish) have addressed the second. These new water-based finishes use polymers whose atomic structures have been rearranged so that they will interconnect, unaided by catalysts, forming a strong network of bonded molecules.—*T. O. B.*

thick that you should wipe rather than brush them on. And the drying times are extended ["Gel Stains," Feb. '89]. "The good news," says Oppenheim, "is that you no longer need a presealer on softwoods because the gels stain much more evenly."

That kind of tradeoff is common in VOC-compliant alkyd paints too, says Robert Nelson, director of environmental affairs for the NPCA. Here are some other examples.

- Application: Brush out, which is the ability to prevent visible brush strokes, and rolling characteristics are worse with newer alkyd paints. The new products don't flow and level out as the well as older, thinner alkyds. However, like all alkyds, the new paints still have application advantages over latexes: They can be applied over a wider surface-temperature range because they are not formulated with water, and they have better wet-edge retention, which means you can brush back into the paint once it has been applied without getting lap marks as you do with latex.
- Hardness is reduced because the paints' shorter-chain molecules do not polymerize as completely as long-chain molecules. Therefore, the film does not become as rigid.
- Resistance to chalking and fading is reduced because the polymer film is not as stable. But resistance to cracking and peeling is improved because the film is more flexible.
- Mildew resistance is degraded somewhat because there is more organic material on which the mildew can grow. (In a related development, the national Centers for Disease Control has urged the EPA to ban the use of mercury in paints. Mercury is often used as a mildewcide.)
- Holdout, or the ability to resist penetration over porous surfaces, could be worse in the newer paints because they do not set as quickly and have more of an opportunity to penetrate.
- On the positive side, odor is reduced, as is fire hazard.

Also on the positive side, of course, is the fact that the new finishes will pollute the air less. Sherwin-Williams' Bennett thinks that, "In the long run, environmental legislation is obviously the right thing to do, with two caveats: There must be consistent regulations across the country, and we as an industry should not be forced into moving faster than technology allows us to move."

Congress seems to agree: At press time the NPCA's Graves was confident that his association's strict but realistic clean air amendment would be passed by year's end.

SOME MANUFACTURERS OF ARCHITECTURAL COATINGS

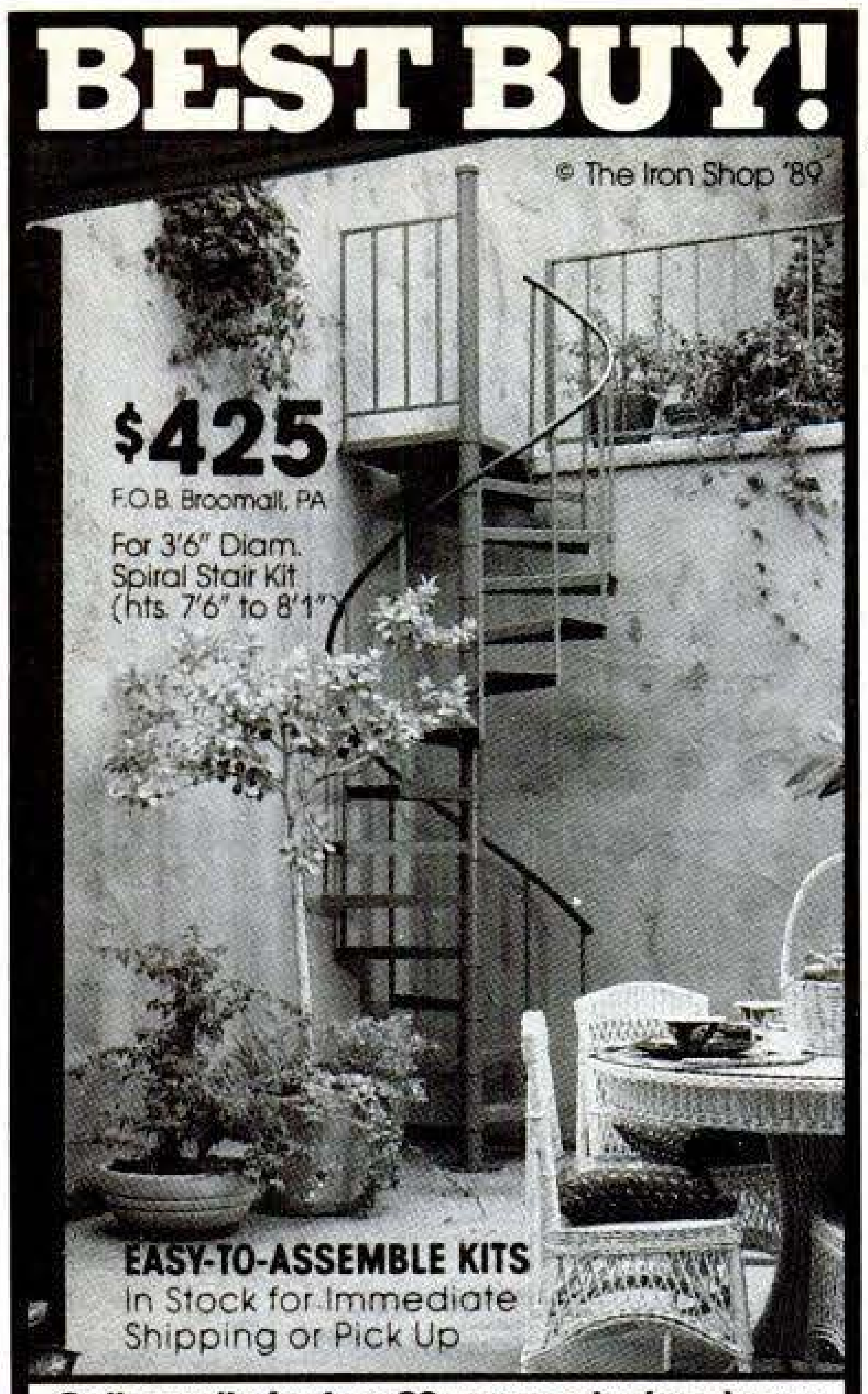
BonaKemi USA, 5450 Joliet St., Denver CO 80239; **De Soto, Inc.,** 1700 S. Mount Prospect Rd., Des Plaines IL 60017; **The Flecto Co.,** Box 12955, Oakland CA 94604; **The Glidden Co.,** 925 Euclid Ave., Cleveland OH 44115; **The McCloskey Corp. (Division of Valspar),** 7600 State Rd., Philadelphia PA 19136; **Minwax Co.,** 102 Chestnut Ridge Plaza, Montvale NJ 07654; **Benjamin Moore & Co.,** 51 Chestnut Ridge Rd., Montvale NJ 07645; **The O'Brien Corp.,** 450 E. Grand St. S., San Francisco CA 94080; **Olympic Stain Co.,** 2233 112th Ave. N.E., Bellevue WA 98004; **PPG Industries,** 1 PPG Pl., Pittsburgh PA 15272; **Pratt & Lambert,** 75 Tonawanda St., Buffalo NY 14207; **Sherwin-Williams,** 1101 Prospect Ave., Cleveland OH 44115

VOLATILE ORGANIC COMPOUNDS AND INDUSTRIAL MAINTENANCE COATINGS

Regulations governing VOC emissions apply not only to household paints and finishes but to coatings for structures like bridges and industrial plants as well. According to Sherwin-Williams' Carroll Bennett, the two most popular and rugged products, vinyl and chlorinated-rubber coatings, which are resistant to acids and other corrosive chemicals, cannot currently be reformulated to meet VOC restrictions. And, Bennett says, there are no viable water-borne systems to replace them as yet. The Golden Gate bridge, for example, stands scarred by gray primer, waiting until a safe coating can be found for it. But according to Parke Schaffer, general manager of Inorganic Coatings in Malvern, Pa., New York is painting the Hudson River's Tappan Zee Bridge with a water-borne high-ratio zinc silicate primer that has been newly formulated by NASA and a new acrylic top coat, both sold by his company.

In another development, Epolin, Inc., headquartered in Newark, N.J., has developed a low-VOC corrosion-resistant polymer coating that is tough enough to be used on jet aircraft. It exhibits a unique feature: When it cures, it expands slightly. Other coatings shrink when their component molecules, called monomers, form long-chain polymers as they turn from a liquid to a solid state. During this polymerization, the chemical bonds become more closely spaced than in the uncombined monomers, thus the compression. During shrinkage the coatings may crack, and on a microscopic level they tend to adhere to the higher levels of a surface, leaving the valleys unprotected.

Epolin based its product research on polymer work done at the University of Maryland. In its stretching aerospace finish, the monomers are in the shape of tight rings. As they polymerize in the presence of ultraviolet light, the monomers open up to form polymer chains, expanding to a minute degree. The company is forging ahead with plans to develop a commercial alternative to solvent-based paints, according to vice president Dr. Morton S. Lefar, although those products are still in the distant future.—*T. O. B.*



BEST BUY!

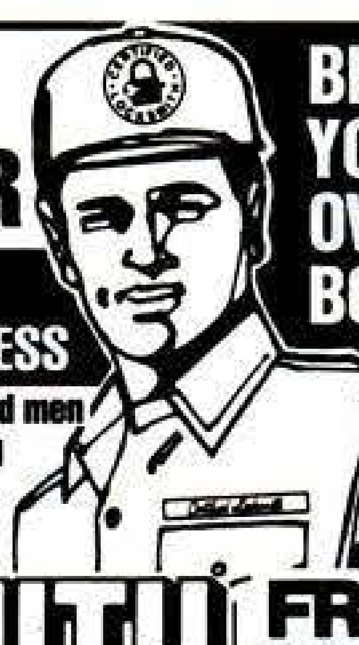
© The Iron Shop '89

$425
F.O.B. Broomall, PA
For 3'6" Diam.
Spiral Stair Kit
(hts. 7'6" to 8'1")

EASY-TO-ASSEMBLE KITS
In Stock for Immediate
Shipping or Pick Up

Call or write for free 20 page color brochure:
THE IRON SHOP Dept. PS80 (215) 544-7100
Box 547, 400 Reed Road, Broomall, PA 19008
Now! Showroom/Warehouse Locations In:
Pomona, CA (714) 598-5766 Sarasota, FL (813) 923-1479
Houston, TX (713) 789-0648 Chicago, IL (708) 952-9010
NEW Stamford, CT (203) 325-8466

THE IRON SHOP®
MANUFACTURERS



MAKE UP TO $26.00 an HOUR

START YOUR OWN MONEY MAKING BUSINESS

BE YOUR OWN BOSS

Hundreds of FOLEY-BELSAW trained men have succeeded in this fascinating and highly profitable field...

You Can Do It Too! ... BE A LOCKSMITH

Never before have money-making opportunities been so great for qualified Locksmiths. Now lucrative regular lock and key business has multiplied a thousandfold as millions seek more protection against zooming crime. **Yet there's only one Locksmith for every 17,000 people!** Train **FAST** at Home — Collect **CASH PROFITS** Right Away. You're in business ready to earn up to $26.00 an hour a few days after you begin Foley-Belsaw's shortcut training. Take advantage of today's unprecedented opportunities in Locksmithing for year-round **EXTRA INCOME** in spare time — or full time in a high-profit business of your own. Hundreds we've trained have done it. So can YOU! All tools plus professional Key Machine given you with course. These plus practice materials and equipment, plus simple, illustrated lessons, plus expert supervision, plus business-building guidance will enable you to **KEEP THE MONEY COMING IN!** Ideal for retirement — good jobs, too.

SEND FOR EXCITING FACTS — NO OBLIGATION!
PRO KEY MACHINE YOURS TO KEEP FREE

This machine can add up to $200 a month to your income... it won't cost you a penny extra with your training.

FIND OUT ABOUT IT
RUSH COUPON TODAY

FREE BOOKLET
KEYS TO YOUR FUTURE

Tells how you quickly train to be your own boss in a profitable Sparetime or Full-time business of your own.

SEND FOR YOUR COPY TODAY!

30 DAY NO RISK TRIAL
ALL SPECIAL TOOLS AND EQUIPMENT INCLUDED

FOLEY BELSAW

FOLEY-BELSAW INSTITUTE
6301 EQUITABLE RD., DEPT. 11841
KANSAS CITY, MO. 64120

There is NO OBLIGATION ★ NO SALESMAN Will Call - ever!

FREE
KEYS TO YOUR FUTURE
TELLS HOW TO MAKE MONEY IN LOCKSMITHING ALMOST FROM THE START!

FOLEY-BELSAW INSTITUTE
6301 EQUITABLE RD., DEPT. 11841
KANSAS CITY, MO. 64120
PLEASE RUSH FREE BOOK *"Keys To Your Future"*

NAME ______________________
ADDRESS ______________________
CITY-STATE-ZIP ______________________

Sun racers

[Continued from page 53]

It remains to be seen whether this innovative design can run through a rough section of road without losing control or sustaining damage. "We tested it on a cobblestone road, and it is stable and durable," says Quadrini. "If the suspension develops a hairline fracture we can repair or replace it in less than two hours."

Repairs on the road

That would be a major setback. According to race director George Ettenheim's speed estimates, the race will proceed at a pace of about 30 mph —slower than the Australian race due to lower levels of sunlight and a route with more hill climbing. At this rate, Quadrini's theoretical two-hour repair could cost the team 60 miles, sending SunDragon to the back of the pack.

Making up that distance will mean running at close to the limit for the remainder of the day. As far as top speed goes, Western Washington University's Viking XX is indicative of the pack of solar cars. While capable of running faster than the race's 55-mph speed limit, it will be at the expense of draining the batteries. The team's strategy will be to maintain a cruising speed of around 40 mph, saving battery power for short bursts of speed.

Piacesi says The Pride of Maryland can cruise at about 40 mph on level terrain under good sunlight without using any battery power. The key is a combination of the power trackers that keep the solar array at peak efficiency and the car's direct-current brushless motor built by Unique Mobility of Englewood, Colo. At 13.5 pounds, this motor boasts a peak efficiency rating of 96 percent. About half of the solar cars will be driven by this 20-horsepower motor, though even under the most strenuous conditions no more than about four hp will be used. According to Quadrini, "It has all the power we'll need and more."

While the Unique Mobility motor is small and light enough to be easily held in your hand, it requires a controller that supplies pulse-width modulated power keyed to the motor's speed to optimize performance. Teams using the Unique Mobility motor and controller system get a fringe benefit—regenerative charging all the way down to zero mph.

Church of Rose-Hulman thinks that the Unique Mobility motor and controller (up to 34 pounds by itself) are overkill and a luxury the team's ultralight entry cannot afford. So the Solar Phantom uses a compact three-hp motor fed by a small controller that weighs less than 10 pounds. "We're going to be extremely stingy on both weight and power with this car," says Church. Still he expects to be able to compete wheel to wheel with the heavier, more powerful cars.

The Solar Phantom will, like many others, drive a single rear wheel. But while the majority will use a chain to link the motor and wheel directly, Church's car will use a five-speed hub from a touring bicycle with internal planetary gearsets, like those on an automatic automotive transmission. With five available gear ratios, Church hopes to use the transmission to keep the motor close to its most efficient operating speed. Another innovation that has spilled over from automotive technology is the continuously variable transmission that Stanford University is currently working with, according to student coordinator Heck. Operating on the same principle as the transmission in the Subaru Justy ECVT, it does fixed gear transmisions one better by providing an infinite variety of gear ratios.

Knowing the route

Knowing the twists and turns of the route will also be a definite advantage. Last summer the Sunraycer traveled some of the roads the race will cover, and Drexel's Quadrini was there, video camera in hand. He has compiled the data into an optimization program that will attempt to preserve battery charge. Here's how it works: A computer in the chase van keeps track of performance data, including speed, power consumption, and power generation. It compares actual data with the theoretical optimum for a perfect energy-saving drive, and the operator radios the driver to adjust his driving technique.

How will each team fare in this 11-day endurance contest? It's anyone's guess, but several cars appear to be at an advantage under certain conditions.

- The two-person Viking XX with its large energy-collecting array could run past the pack traveling north on a sunny day, but could lose ground when the road bends to the east or west.
- The lightweights, like the Drexel SunDragon and Rose-Hulman Solar Phantom, could break into the lead in hilly areas with their Spartan designs.
- The University of Maryland car should be a contender on rough roads.
- The Stanford SunSurfer might be able to overhelm the competition with its efficient solar array.

For the top finishers of this race, the competition will not be ending, but just beginning. Three teams will win GM sponsorship to compete in the World Solar Challenge in Australia this November. PS

Material wealth

[Continued from page 83]

roof. Flanges formed into the edges of these pieces offer attachment points for sheet metal, and interior webbing increases bending strength. The extrusions, developed by Japan's Kobe Steel Co. Ltd., not only minimize weight, they offer a relatively simple solution to the problem of stiffening the chassis for a convertible version—simply by thickening the cross section of the frame rails.

The skin is a special alloy that is hardened by the heat of the paint ovens, theoretically developing a ding-resistance close to steel's. Special attention was paid to eliminating the possibility of galvanic corrosion, and a chromate-based primer system is used under some 23 coats of paint. The sheet aluminum is formed by conventional steel dies, although special welding techniques were required.

High output, low noise

My second surprise came when I investigated the 270-horsepower dual-overhead-cam V6. It's located about a foot behind the driver's seat, but all you can hear is a pleasantly muted growl. Despite a fairly high power peak (270 hp at 7,100 rpm, with 210 pound-feet of torque at 5,300 rpm), the NSX power plant is the model of flexibility. The nearly flat torque curve is due to several factors, including a high 10.2:1 compression ratio, a two-stage induction system, and a variable valve timing system that shifts each cam follower to another high-speed cam lobe at about 5,800 rpm ["Variable Valve Timing," March].

By keeping the weight of reciprocating parts to a minimum—titanium connecting rods are 6.7 ounces lighter than steel ones—the engine effortlessly revs to the 8,000-rpm (manual-transmission model) redline.

Power is kept in check by a traction control system that reduces output both at the onset of wheelspin and in hard corners. The automatic-transmission version of the NSX gets the first application of all-electric power steering, which uses an electronically controlled armature driving a screw jack, rather than a conventional hydraulic system. Sophisticated electronic circuitry tapers off the steering boost at higher speeds, though the chosen cutoff speed is a little high.

Despite the new ground broken in a half-dozen different technical areas, the NSX manages a kind of harmony and balance that makes all these systems work together in a smooth, flowing whole—an achievement that makes it likely the NSX will quickly become one of those cars measured against the best. PS

Deep cover

[Continued from page 57]

tegrated circuits and optical fibers for data signals.

There's strong disagreement among experts whether the Seawolf's combined technology will be adequate against upcoming—or even current—Soviet subs. Some analysts estimate Soviet Akula-class subs can travel at 42 knots, raising the prospect that these also have a high quiet speed. Other titanium-hull Soviet subs could dive deeper than steel-hull Seawolfs. McKee called the Akula "a significant breakthrough in performance. The Akula going to sea represents a substantial decrease in our advantage," he said.

Other Pentagon officials have dubbed the Akula a "Walker-class" sub, after the Walker spy ring that betrayed U.S. naval secrets and helped the Soviets build quieter submarines.

Does Soviet sub quieting include water-jet-propulsion magnetic drives? With this technique, called magnetohydrodynamic (MHD) drive, electrified sea water flowing through a magnet would be propelled backward, pushing the magnet and vessel forward. Argonne National Laboratory is experimenting with MHD for the defense department [Science Newsfront, March].

Soviet secrets

The mysterious pods on the vertical rudder of Soviet Victor III, Sierra, and Akula sub classes have been described for years as a housing for a towed sonar array or very-low-frequency antenna, as well as an MHD drive. In March, *Navy News* said experts analyzing detailed pod photographs concluded that it is an MHD drive. Information from a defecting Soviet submarine designer, an MHD specialist, supported their conclusion. By one estimate, the pods could silently push Soviet submarines at six to eight knots when exceptionally quiet patroling is necessary.

The race for quiet subs continues. Ralph Chatham, formerly of the Defense Advanced Research Projects Agency, who led the search for new anti-submarine technologies, cautions we're moving toward a world where the subs of all military powers will be almost undetectable. How would we carry out anti-submarine warfare during conflicts? His answer: We wouldn't. Nations would attack each other's surface fleets, with one Navy as vulnerable as another. That might prove to be a recipe for a mutual assured destruction that would deter war at sea during the next century. PS

MAIL THIS COUPON FOR FREE FACTS!
TRAIN AT HOME FOR A BETTER CAREER
42 ways ICS can help you improve your life

Rush free facts and color brochure on how I can train at home for the career I have chosen. I understand I am under no obligation and no salesman will visit me. CHECK ONE BOX ONLY!

ASSOCIATE IN SPECIALIZED BUSINESS DEGREE PROGRAMS
☐ Business Management
☐ Accounting
☐ Business Management with option in Finance
☐ Business Management with option in Marketing

ASSOCIATE IN SPECIALIZED TECHNOLOGY DEGREE PROGRAMS
☐ Civil Engineering Tech.
☐ Mechanical Engineering Technology
☐ Electrical Engineering Technology
☐ Electronics Technology

CAREER DIPLOMA PROGRAMS
☐ Computer Programming
☐ Personal Computer Specialist
☐ High School
☐ Bookkeeping
☐ Secretarial
☐ Medical/Dental Office Assistant
☐ Legal Secretary
☐ Fashion Merchandising
☐ Auto Mechanics
☐ Hotel/Restaurant Management
☐ Child Day Care Management
☐ Legal Assistant
☐ TV/VCR Repair
☐ Surveying & Mapping
☐ Catering/Gourmet Cooking
☐ Fitness & Nutrition
☐ Small Business Management
☐ Drafting
☐ Air Conditioning & Refrigeration
☐ Microcomputer Repair
☐ Electronics
☐ Travel Agent
☐ Police Sciences
☐ Art
☐ Wildlife/Forestry Conservation
☐ Veterinary Assistant
☐ Diesel Mechanics
☐ Electrician
☐ Interior Decorating
☐ Motorcycle Repair
☐ Gun Repair
☐ Photography
☐ Journalism/Short Story Writing
☐ Dressmaking & Design

712ZC

Name ______ Age ______
Address ______ Apt. # ______
City/State ______ Zip ______
Phone ( ) ______

ICS SINCE 1890 International Correspondence Schools
Dept. PCS70, 925 Oak St., Scranton, PA 18515
A Subsidiary of National Education Corporation

WoodKarry
by EEGLE RESEARCH INC.
$24.95

The easy way to carry those long awkward loads. Wood, Pipe, Ladders, Etc.

Covered with soft vinyl to protect your cars finish. Designed to contour to the shape of your car.

SEND TO: EEGLE RESEARCH INC.
Main P.O. Box #1736, Niagara Falls, N.Y. ZIP 14302
Phone # (416)-347-5868
ONLY $24.95 U.S. + $6.00 Shipping & handling.
Ontario residents add 8% sales tax.
Sorry, no C.O.D. orders.
PLEASE CHECK: __ Check or Money Order
PLEASE PRINT CLEARLY

Name ______
Address ______ Apt. # ______
City ______
State ______ ZIP ______
Phone ( ) ______
Sign Here ______

"Say, Smokey—"

A clinic on cars by Smokey Yunick, America's most famous mechanic

A stiff belt

I've been told that Honda has developed a timing belt for new models that will supposedly last the life of the car. Why aren't other auto makers using this solution to overcome the problem of short belt life?

John Engelhardt, Coram, N.Y.

A number of manufacturers now call for timing belts to be changed at 60,000 mile intervals. This seems like smart insurance to me because in many engines the valves will hit the piston and bend or break if the belt fails. Preventive maintenance of the belts is the best bet, no matter how long the manufacturer claims they'll last.

Oil bypass

Would it be beneficial to plug the oil bypass on a 1969 Chevrolet Camaro Z28 so that all the oil is sent right to the filter?

David Voros
Santa Barbara, Calif.

The are two main reasons for the use of an oil-pressure relief system: to keep from blowing the oil filter on a cold start when pressure is at its highest, and to prevent oil starvation in the event that the filter gets plugged with dirt. Race cars can do without the bypass because their engines are not started with cold oil, and oil is changed frequently. Because the engines in road cars must withstand different conditions, it's probably best to leave the filter bypass operational.

Propane questions

I have a truck with a 1978 GM six-cylinder 250-cubic-inch displacement engine that was converted to run on propane before I bought it. Would it be a good idea to optimize the engine to run on this fuel?

Brian Williams, Toronto, Ont.

Propane burns a lot cleaner than gasoline and may aid engine durability because it doesn't dilute the oil like gasoline can. It has an octane rating of over 100, so it can take more compression and ignition timing advance. The problem is that its chemical heat content is less than gasoline's, and even if you optimize it, you'll need to fill up more often. Changing the cam profile can increase power, but I doubt it will increase thermal efficiency enough to make up for the shorter range of an equivalent propane-fueled vehicle. You definitely need hardened valves and seats, not for temperature reasons, but to make up for the lack of valve face lubricants present in gas.

Oil crisis

When the four-cylinder engine of my Pontiac Sunbird overheated at 50,000 miles, the mechanic replaced the head gasket and did a valve job. The engine then began to use about 1½ quarts of oil between every gas fill-up, which it had never done before. What could be wrong with the engine?

Tony Van Bo, Norman, Okla.

Sorry to say, this increase in oil consumption after doing a valve job happens often. The valve job has improved manifold vacuum, causing the oil to be pulled past the rings. If it was my car, I'd pull the head and install new rings to stop the leakage. As hot as that engine was run, you'll probably find other damage that needs to be corrected.

Turn for the worse

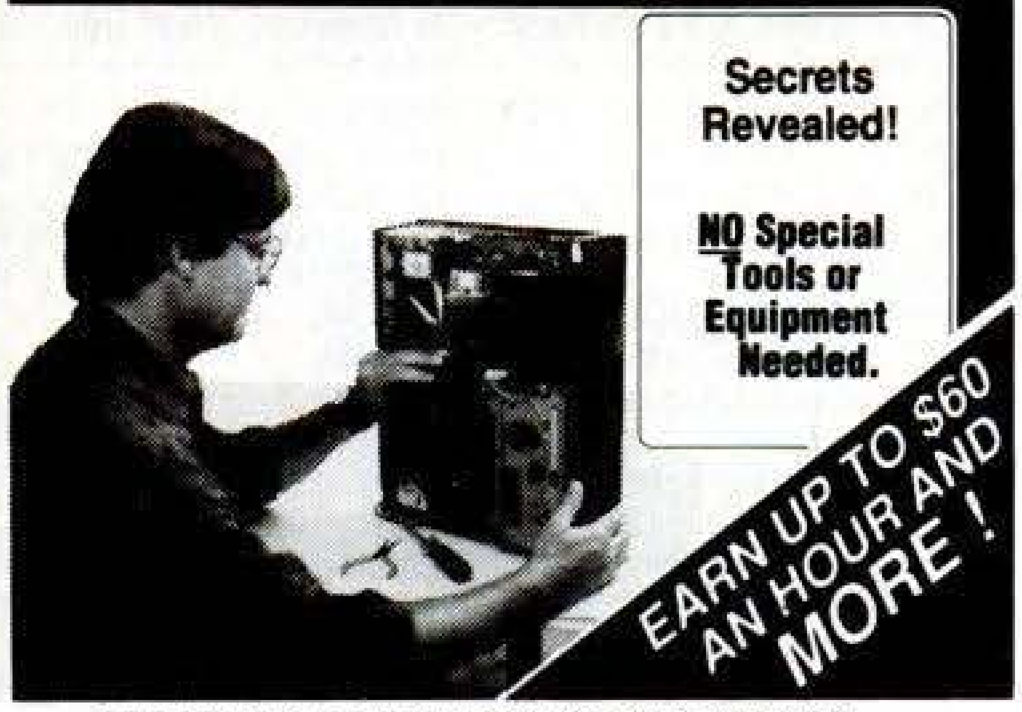
The rotary engine in my Mazda RX-7 sometimes stalls when I make hard right turns, when going over speed bumps, or on hard braking. It doesn't matter whether the clutch is engaged or not.

Mark Warsaw, Plantation, Fla.

I'd start by looking at the fuel supply system for an interruption of fuel flow due to centrifugal force or rapid deceleration. Carefully check the entire fuel-delivery system and gasoline tank for a fuel-pickup problem. In view of the fact that the engine is only affected by right-hand turns, look for a sharp right-hand bend in a fuel line.

Got a car problem? Send it to "Say, Smokey—," POPULAR SCIENCE, 2 Park Ave., New York, N.Y. 10016. All letters are read, and those of widest interest are answered in this column. Due to the large volume of mail, Smokey cannot reply to letters not selected for publication.

LEARN VCR
CLEANING/MAINTENANCE/REPAIR
EARN UP TO $1000 A WEEK, WORKING PART TIME FROM YOUR OWN HOME!

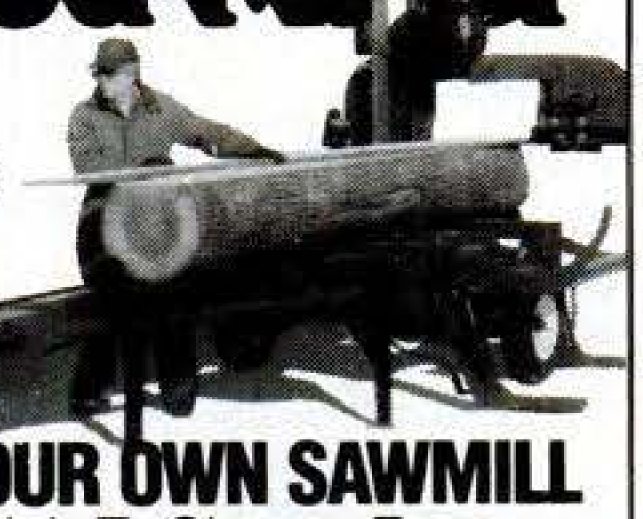

Secrets Revealed!
NO Special Tools or Equipment Needed.
EARN UP TO $60 AN HOUR AND MORE!

THE MONEY MAKING OPPORTUNITY OF THE 1990'S

IF you are able to work with common small hand tools,
IF you possess average mechanical ability, and have a VCR on which to practice and learn.... then we can teach ***YOU*** VCR maintenance and repair!
FACT: up to 90% of ALL VCR malfunctions are due to simple MECHANICAL or ELECTRO-MECHANICAL breakdowns!
FACT: over 77 million VCRs in use today nationwide! Average VCR needs service or repair every 12 to 18 months!
Viejo's **400 PAGE TRAINING MANUAL** (over 500 photos and illustrations) and **AWARD-WINNING VIDEO TRAINING TAPE** reveals the **SECRETS** of VCR maintenance and repair - "real world" information that is **NOT** available elsewhere!
Also includes all the info you'll need regarding the BUSINESS-SIDE of running a successful service operation!

FREE INFORMATION
CALL TOLL-FREE 1-800-537-0589
Or write to: Viejo Publications Inc.
3540 Wilshire BL. STE. 310
Los Angeles, CA 90010 Dept. PS

Wood-Mizer®
World's Largest Manufacturer Of Portable Sawmills



OWN YOUR OWN SAWMILL
Four Models To Choose From
BUY DIRECT
1(800)553-0219
In Indiana call: (317) 271-1542
FREE 44-page catalog or use your MasterCard or VISA to order our 50-minute demonstration video–$10.00

Wood-Mizer Products, Inc. • Dept. E50
8180 W. 10th St., Indianapolis, IN 46214-2430

CABLE T.V. DESCRAMBLER
How You Can Save Money on Cable Rental Fees

Jerrold, Pioneer, Scientific Atlanta, Oak, Zenith, Eagle and other famous manufacturers
Best Retail/Wholesale Prices
30 days money back guarantee
FREE 16 page Catalog
Call Toll Free: 1-800-445-9285
U.S.Cable T.V. Inc. Dept.KBB8
4100 N.Powerline Rd., Suite F-4
Pompano Beach, FL 33073

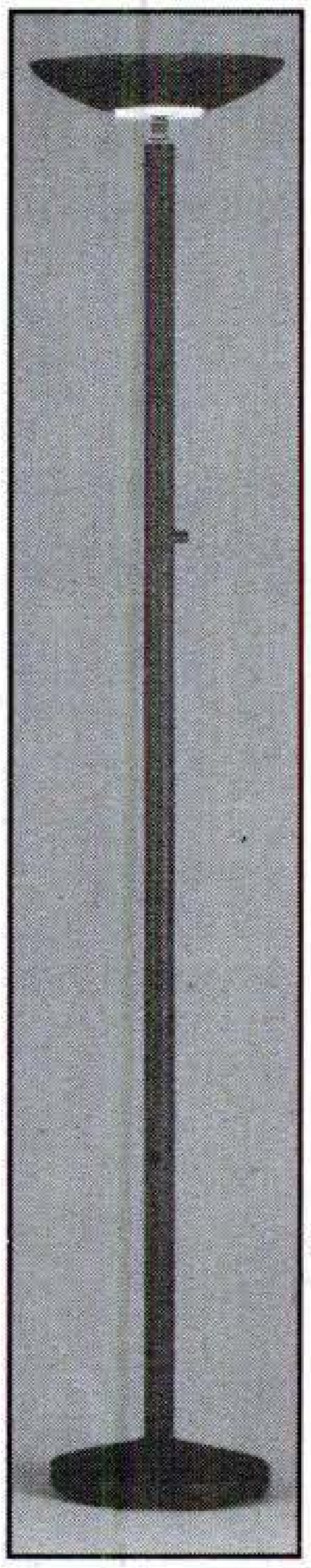
Shoppers' Showcase

A selection of products and services for POPULAR SCIENCE readers available direct by mail. Enjoy the fun and convenience of mail ordering shopping. Please order directly from the advertiser. For advertising rates for this section, write or call Diane Pahl, Direct Response Manager, POPULAR SCIENCE, 755 W. Big Beaver Rd., Suite 420, Troy, MI 48084; (313) 362-9005; fax # (313) 362-3403.

DAMARK

LIMITED QUANTITIES ORDER TODAY!

1-800-729-9000



HALOGEN TORCHIERE FLOOR LAMP

Fill your room with light from this sleek-looking Halogen Torchiere Floor Lamp. It's truly a lamp of the '90s with its lustrous finish and upward positioned shade—and its halogen bulb lasts for hours & hours of use. Light up a room and make a statement with stylish modern design.

- Halogen torchiere floor lamp. • Shines light upward, yet fills entire room. • Variable light control switch.
- 500 Watt halogen bulb included. • U.L. listed.
- Contemporary design.
- Glass insert below shade allows light to shine downward also—for a complete lighting effect.
- Color: Black, white, brass, chrome, or almond.
- Height: Approx. 72".
- **1 Year Mfr. Warranty!**
- **Factory New! & Perfect!**

Mfr. Sugg. Retail: **$170.00**

DAMARK PRICE: $46.99

(Black) Item No. B-2166-127911
(White) Item No. B-2166-130153
(Brass) Item No. B-2166-130161
(Chrome) Item No. B-2166-130179
(Almond) Item No. B-2166-130187
S/H: $9.50

cordata

386SX COMPUTER with VGA MONITOR

- 100% IBM compatible.
- Includes 14" VGA color monitor.
- 80386SX-16/8 MHz speed, upgradable to 20 MHz.
- One 3-1/2" 1.44 MB floppy disk drive.
- One 5-1/4" 1.2 MB floppy disk drive.
- 40 MB hard drive/28 millisecond access time.
- 1 MB RAM on motherboard, expandable to 8 MB.
- Expansion slots: three IBM AT compatible accessory slots; one IBM PC/XT compatible accessory slot.
- Three 1/2" peripheral bay.
- Built-in VGA video support.
- Battery backed real time clock/calendar.
- One serial & one parallel port.
- 80387SX-16 math co-processor socket.
- 101 key IBM style keyboard.
- Zero wait state. • Phoenix BIOS. • Model # CPC8248.
- Included MS-DOS 4.4. • Dim.: 16"Wx18"Dx5"H.
- **One Year Warranty through Cordata.**
- **Factory New! Factory Perfect!**

Mfr. Sugg. Retail: **$2,968.00**

DAMARK PRICE $1499.99

Item No. B-2166-143578 S/H $49.00

Comes Ready to Use!

TRANSPORTABLE CELLULAR TELEPHONE

Powered by a standard 12V cigarette lighter this phone comes ready to use right out of the box.

- **FULLY FEATURED:**
- No installation required! • Full 3 watts of power.
- Status indicators (in-use, roam, horn).
- Electronic lock. • 9 number memory.
- Automatic call retry. • Last number redial.
- Compact water resistant nylon carrying case included.
- **One Yr. Mfr. Warranty! • Factory New! & Perfect!**

Battery Pack & Charger Available:

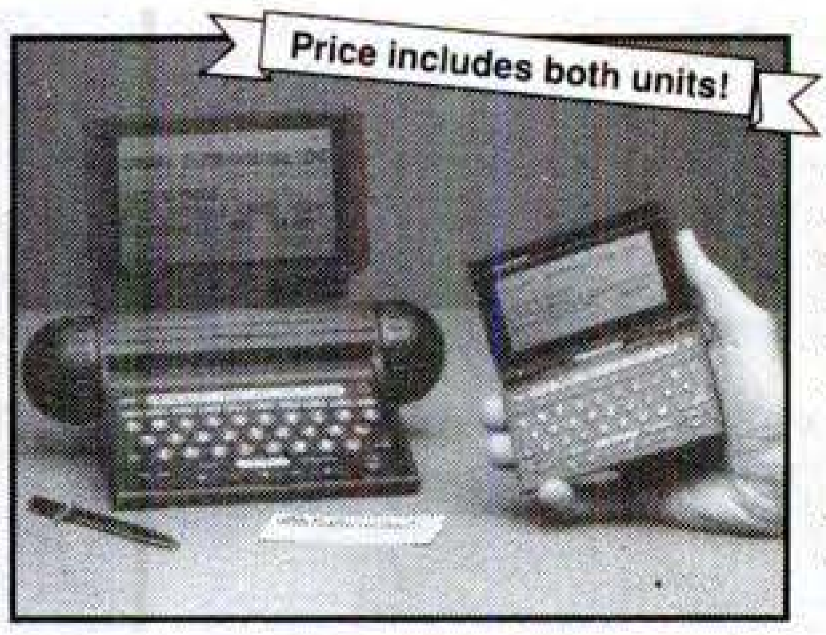
- Ask your operator when placing your order.
- Please have social security number & driver's license number available for operator.

This Transportable Cellular Telephone comes pre-programmed with your local cellular number. Special price is $99.99 which requires a two year new activation and minimum service commitment through International Ventures, Inc. – $399 without activation or where activation requirement is prohibited by law. Subject to credit approval. Phone not available in California, North Carolina & Hawaii.

Mfr. Sugg. Retail: **$599.00**

DAMARK PRICE $99.99

Item No. B-2166-145730 S/H $19.00



Price includes both units!

TELE·ART INSTRUMENTS

THE 64K ELECTRODEX™ & 32K POCKET COMPUTER

64K Electrodex Features:

- Electronic desktop card file & organizer.
- 64K random access memory (64,000 characters).
- Cordless and wireless.
- Rotary dial for easy flip by viewing of business cards.
- AC adapter or 3 "AA" batteries plus 1 lithium back-up battery which provides a no-loss memory back-up system, (all included).
- **90 Day Limited Mfr. Warranty!**
- **Factory New! & Perfect!**

32K Pocket Computer Features:

- Infrared wireless transfer system—transfer files to an associate's or to the desktop 64K. • Powerful 32K RAM (32,000 char).
- Extra large LCD display screen (6 lines x 24 characters per page).
- **7 screen categories**: Business Card File, The Call Sheet, Letters To Write, Reminder Notes, Monthly Calendar, & Currency Converter & Large Screen Calculator.
- Dim.: 5"L x 7"W x 1"D.

Mfr. Sugg. Retail: **$317.00**

DAMARK PRICE $199.99

Item No. B-2166-145904 S/H: $9.50

DAMARK

For Costomer Service, Call: (612) 566-4940

FOR FASTEST SERVICE CALL TOLL FREE

1-800-729-9000

NAME ____________________
ADDRESS ____________________
CITY ____________________ ST _____ ZIP ____________
PHONE ____________________
CARD NO. ____________________ EXP. DATE ____________
SIGNATURE ____________________

Qty	Description	Item #	S/H/I	Price

DELIVERY TO 48 U.S. CONTINENTAL STATES ONLY

SUB TOTAL ______
in MN add 6% Sales Tax ______
Total S/H/I ______
GRAND TOTAL ______

☐ VISA ☐ MasterCard
☐ DISCOVER ☐ Check/Money Order

B-2166

Send To: DAMARK INTERNATIONAL, INC., 6707 Shingle Creek Parkway, Minneapolis, MN 55430

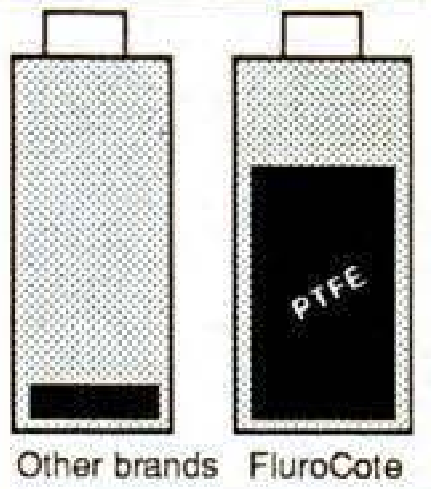
Recycled Paper

Auto Racer Irvin Allen proves FluroCote claims!!

14,000 miles after treating his car with FluroCote Irvin Allen drained the oil out of his Datsun 280Z and drove around a race track 9 times. Oil was then put back in the car and he drove away. The engine was not harmed.

FluroCote Friction Reducing Motor Treatment can give your engine maximum protection. Delays costly time consuming overhauls even in older models. FluroCote is produced using PTFE, the most slippery lubricant known. It is a metal treatment (not an oil additive).

**50,000
More Miles
Of Protection
Engine, Transmission
and Radiator**



COMPARE THE DIFFERENCE
See for yourself why you get more for your money plus the best with FluroCote. One bottle of FluroCote contains appox. 300% more PTFE (polytetrafluoro ethylene) than any leading competitor.

Try it today . . . Treat your engine right !!
FluroCote is one of the newest top quality lubricants available today - proven conclusively by scientific means to stop friction within an engine. The hotter the engine gets the more FluroCote bonds itself to the metal parts of the engine. The tighter the bond the less friction the engine has assuring you of quicker cold starts, less engine drag, better mileage and longer, trouble free dependable engine life.

"Does it work - you bet it does !!"
says Ken Taylor, Pres. of Taylor Enterprises, and FluroCote is backed by a written money back guarantee and insurance policy.

And for only $19.95 8 oz. bottle (+ $2.00 S/H)

Whether it's Racing

High Performance

or highway driving

ONLY ONE TREATMENT EVERY 50,000 MILES
Oil is used as a carrier to coat the metal surfaces. FluroCote is guaranteed to reduce or prevent internal motor friction. Compatible with all petroleum or synthetic oils. Proven by leading auto racers and PTFE was used by the American astronauts on their trip to the moon.

Fluro Cote

Keeps working while you drive.

Street

Off-Road

Harry Hibler, Publisher HOT ROD Magazine says - "I added FluroCote to the crankcase of my Ford Ranchero. Engine idle speed increased by over 100 RPM without any other changes. Am now checking fuel mileage economy."

**ORDER TODAY TOLL FREE
1-800-999-1995**

TEI
TAYLOR ENTERPRISES INTERNATIONAL, INC.
202 W. Hillcrest Ave., San Bernardino, CA 92408

MONEY BACK GUARANTEE IF NOT SATISFIED
Please send me _____ 8 oz. bottles *FluroCote.*
I am enclosing $________ ($19.95 + $2.00 S/H)
Calif. res. add 6% sales tax.
Charge my: Visa___ M/C___ Discover___ Amer. Ex.___
Card #____________________ Exp.Date____________________
Name____
Address____
City____
State ________________ Zip____________________
Signature ____
For complete information send $2.00 refundable on first order.
Mail to: TEI, Inc. Dept. PS
202 W. Hillcrest Ave. - San Bernardino, CA 92408

OWN YOUR OWN HOVERCRAFT

The ***ONLY TRUE*** All Terrain Vehicle!

SCAT HOVERCRAFT, INC. **FLY**

The largest manufacturer of recreational Hovercraft in the world

Over Land, Water Ice, Snow on an 8" Cushion of air

**Call
Toll Free
1-800-541-7228**
For Free Information
SCAT HOVERCRAFT, INC.

DEALER INQUIRES INVITED
6865 N.W. 36 Ave.
Miami, FL 33147

★★★★★ PRESENTING ★★★★★
CABLE TV EQUIPMENT
★★★★★ STARRING ★★★★★
JERROLD, HAMLIN, OAK
AND OTHER FAMOUS MANUFACTURERS
- FINEST WARRANTY PROGRAM AVAILABLE
- LOWEST RETAIL/WHOLESALE PRICES IN U.S.
- ORDERS SHIPPED FROM STOCK WITHIN 24 HOURS

FOR FREE CATALOG ONLY **1-800-345-8927**
FOR ALL INFORMATION **1-818-716-5914**

PACIFIC CABLE CO. INC.
7325 1/2 RESEDA BLVD DEPT 1446
RESEDA, CA 91335

VISA

WOOD HEAT

**WOOD FURNACES
HEAT YOUR ENTIRE HOME**
Call 1-218-326-6786 or Write
Charmaster®
2307 C HWY 2 W.
GRAND RAPIDS, MN 55744

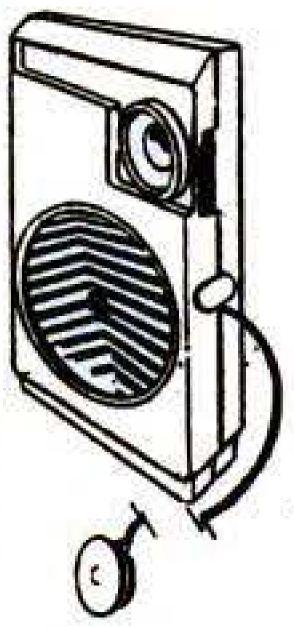
FREEZER ALARM

Life Insurance For Your Frozen Food
By the G & D FREEZER ALARM
"Satisfaction Guaranteed"

If your freezer quit last week, would you know it? Avoid the loss with a **G & D FREEZER ALARM.** Whether a electrical or mechanical failure, or only a door ajar, this compact device will warn you when freezer temperature exceeds 20°F. This gives plenty of time to have your freezer repaired, or to transport food. Gone all day? This unit will alarm for three days on one 9 V. Battery! Installs in a minute, built to last a lifetime! Features a time delay setting for use on frequently used freezers, and refrigerator/freezers.

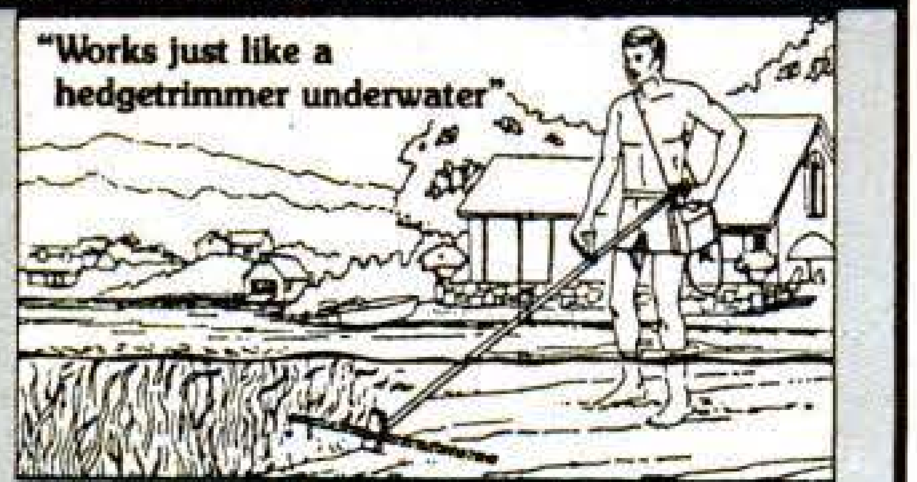
Only $29.95 (Ca. add tax) + $3.00 s/h

**G & D ENTERPRISES 2178 MANSELL
P.O. BOX 1914 QUINCY, CA 95971**



Control Water Weeds

Amazing new Underwater Harvesting Tool!
the **WATER-WEEDER™** *Harvester*


"Works just like a hedgetrimmer underwater"

Cut aquatic vegetation from a boat, from a dock or simply by wading in from shore. Control weed growth the *environmentally safe way.*

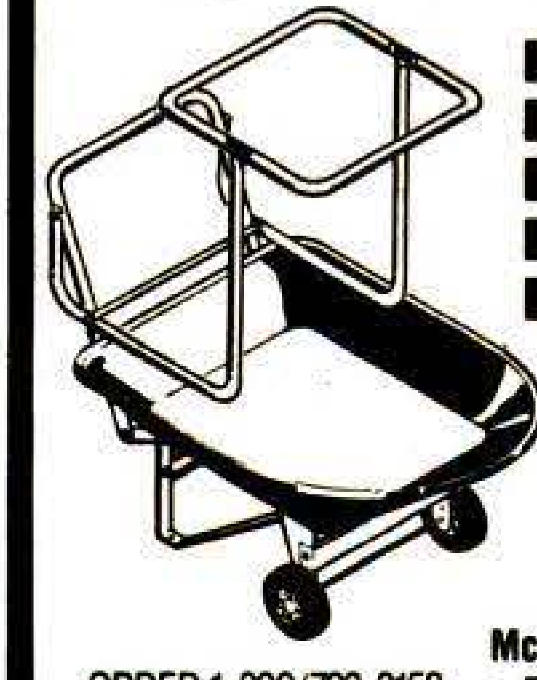
Satisfaction Guaranteed or money back!

Call or write today for **FREE** information package.
TOLL FREE 1-800-552-1217

Waterside Products™ Corp.
P.O. Box 876, Lake Mahopac, New York 10541

REMARKABLE NEW YARD CART WITH REMOVABLE BAG HOLDER

Bag slides easily to ground!



- **4 cu. ft. poly tray.**
- **Holds up to 250 lbs.**
- **Adjusts for bag size.**
- **Durable rubber tires.**
- **Sturdy, lightweight.**

$49⁹⁵ freight included.

Cal. res. add 6.75% tax.
Check, Visa, MasterCard.
Allow 3 weeks delivery.

ORDER:1-800/733-8158
9 to 4 Pacific time.

**McLane Manufacturing, Inc.
7110 E. Rosecrans Ave.
Paramount, CA 90723**

ARCO Solar ◆ Electric Panels — As Low As $157. *DELIVERED!*

PHOTOVOLTAIC POWER FOR HOMES, CABINS, RV's & MORE

- *Available In 35, 40, 100 Watts.*
- *Previously Used In Power Plants.*
- *Full 5 Year Warranty.*

Call 1-800-223-9580 Ext. 10

Or Write:
PHOTOCOMM, INC.
Dept. 10, 7681 Gray Road
Scottsdale, AZ 85260
66 Page Catalog — $2

ROLEX

President "Look-Alike"

An Exact Replica! Gold-tone, Day, Date, Hidden Clasp, Simulated Diamonds, State-of-the-Art Quartz Movement. Easily confused with the real 18K Gold Rolex. Ladies' or men's. Only $39.95 (add $5.00 post/hndlg/insur. In CA, add $2.60 tax). COD-OK. Call 1-800-648-4600 or send check to: TELAMAR, 9016 Wilshire Blvd., Ste. 828-Z , Beverly Hills, CA 90211

REPLICA MODELS

HISTORIC NON-FIRING MODEL GUNS . . .

Safe! Full size. Zinc alloy. Realistic. Over 30 parts. Cannot chamber or fire real ammo. Assembled. FREE Catalog.

COLLECTOR'S ARMOURY
800 Slaters Lane
Box 59, Dept. P.S
Alexandria, VA 22313

Credit Card Orders:
1-800-544-3456 Ext. 515
Toll Free 24 Hrs.

U.S.M1911
.45 AUTO.
$107 PPD.
Length: 8.5"
Weight: 41 oz.

PLASTI DIP® CUSHIONS TOOLS

Cushion your tools for a firmer, more comfortable grip. Coat handles with flexible PLASTI DIP. Won't chip, crack or peel. Many colors.

PLASTI DIP at leading Hardware & Home Centers nationwide.

PDI P.O. BOX 130
CIRCLE PINES, MN 55014

FREE CATALOG!

1-800-648-7938

JERROLD HAMLIN OAK ETC

CABLE TV EQUIPMENT

- *Special Dealer Prices!*
- *Compare our Low Retail Prices!*
- *Guaranteed Prices & Warranties!*
- *Orders Shipped Immediately!*

REPUBLIC CABLE PRODUCTS, INC.
4080 Paradise Rd: #15, Dept. 509
Las Vegas, NV 89109
For all other information (702) 362-9026

AMAZING 1791b flying machine **CLIMBS** to 10,000 feet **NO LICENSE** required **NO WINGS** or Helicopter blades **COMPLETELY TRANSPORTABLE** **SAFEST**, Easiest, Cheapest way to fly for complete info + **FREE** Demo flight send $5.95 to: Freedom Fliers, P.O. Box 135 , West-Pittston, PA 18643. (Buy One Be A Dealer If Open.)

Popular Science Indexes
Box 2451, West Chester, Pa. 19380.
Enclosed is a total of $________(check or money order) Please send:
☐'88 ☐'87 ☐'86 ☐'85 ☐'84 ☐'83 ☐'82 ☐'81
☐'80 ☐'79 ☐'78 ☐'77 ☐'76 ☐'75 ☐'74 ☐'73 ☐72
($1.75 each) ☐All 17 indexes (1972-1988) for $17 ☐Five indexes $5
Name________________
Address________________
City________________
State____________Zip______
(Prices above include postage and handling. Allow about 4 weeks for delivery.)

YOU SAW IT IN POPULAR SCIENCE —BUT WHEN?

CABLE TV

DESCRAMBLER KITS

JERROLD SB-3 TYPE.	$29.00
JERROLD TRI-MODE	39.00
UNIVERSAL TYPE.	CALL

58 Channel
CABLE CONVERTER. $69.95
Jerrold 400 with remote control
Re-manufactured with new remote

CALL TOLL FREE
1-800-332-3557

VISA, MasterCard and COD.
FREE CATALOG
Outside USA call 1-508-699-6935
add $3.50 S+H, $6.00 outside USA.
D & D Electronics, Inc.
VISA PO Box 3310-DP MC
N. Attleboro, Ma. 02761

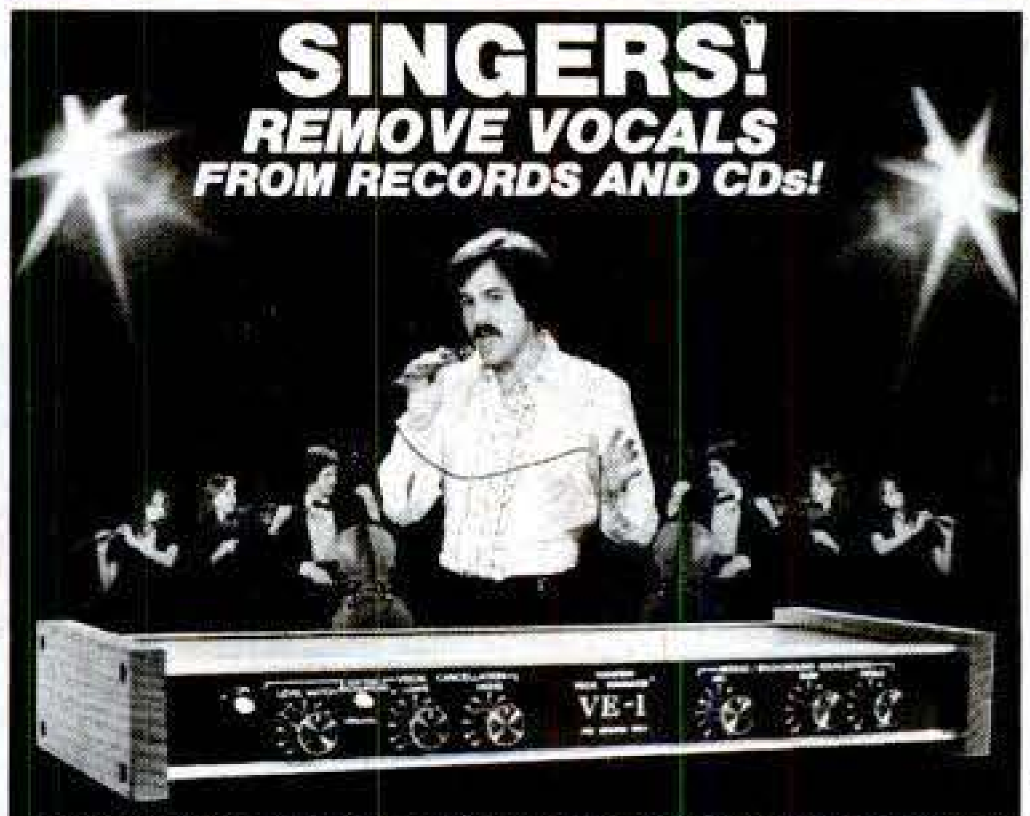
Do It Yourself DOMES

1500 sq.ft. home plans & fully engineered connecting hardware—**$3250.** Complete precut kits and a variety of floorplans available. Attractive, easy-to-assemble, energy-efficient. New 40-page color catalog & more—**$12.**

TIMBERLINE GEODESICS
2015 Blake St., Berkeley, CA 94704 1-800-DOMEKIT

SINGERS!

REMOVE VOCALS FROM RECORDS AND CDs!



SING WITH THE WORLD'S BEST BANDS!

An Unlimited supply of Backgrounds from standard stereo records! Record with your voice or perform live with the backgrounds. Used in Professional Performance yet connects easily to a home component stereo. This unique product is manufactured and sold Exclusively by LT Sound - Not sold through dealers. Call or write for a Free Brochure and Demo Record.

LT Sound, Dept. PS-3, 7980 LT Parkway
Lithonia, GA 30058 (404) 482-4724
Manufactured and Sold Exclusively by LT Sound
24 HOUR PHONE DEMO LINE: (404) 482-2485

CABLE TV DESCRAMBLER LIQUIDATION!

- Major Makes & Models!
- Will match or beat anyone's prices!
- Dealer discounts at 5 units!
- Examples:

HAMLIN COMBOS .	$44 ea.	(Min. 5)
OAK ADD/ON	$40 ea.	(Min. 5)
OAK M35B	$60 ea.	(Min. 5)

WEST COAST ELECTRONICS
For Information: 818-709-1758
Catalogs & Orders: 800-628-9656

NOW! Get in on the PROFITS in SMALL ENGINE REPAIR

Start your own money making business!

Work part time, full time — right at home — we help you every step of the way.

No doubt about it . . . as a small engine pro, you can cash in on the huge demand for qualified men in one of America's fastest growing industries. You'll be able to command top hourly rates of from $25.00 to $30.00 per hour — and that's just for labor.

Plenty of business waiting for qualified men. 65,000,000 Small Engines Are In Use Today!

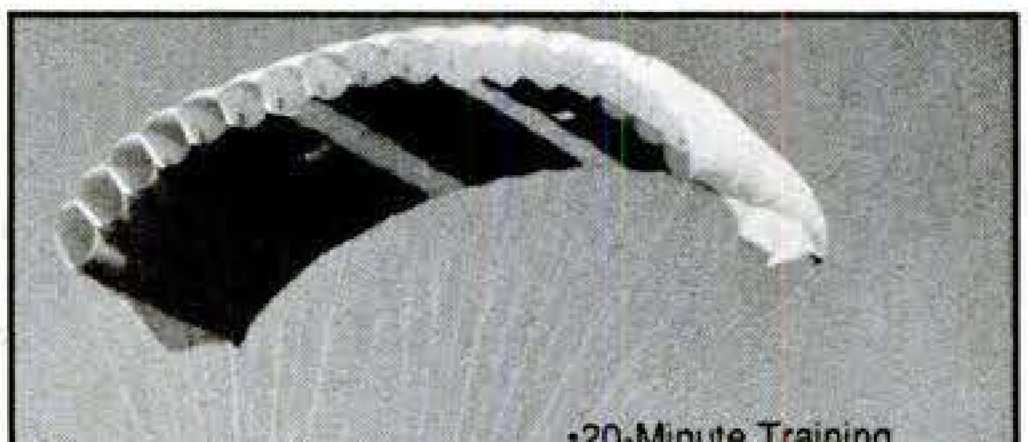
That's the official count from the Engine Service Assn., and one-million new engines are being built each month. With Foley-Belsaw training, you can soon have the skill and knowledge to make top money servicing these engines.

Professional Tools and Equipment PLUS 4 hp Engine . . . .
All YOURS TO KEEP . . . . All at No Extra Cost.

NO EXPERIENCE NECESSARY!

You don't need to be a 'born mechanic' or have any prior experience. Lessons are fully illustrated . . . so clear you can't go wrong, and with our famous 'learn-by-doing' method you get practical 'hands-on' experience.

Foley-Belsaw Institute, 6301 Equitable Rd.
Dept. 51860, K.C., MO 64120
☐ YES, please send me the FREE booklet that gives full details about starting my own business in Small Engine Repair. I understand there is No Obligation and that No Salesman will call on me.
FREE BOOKLET! Send for your copy today!
NAME________________
ADDRESS________________
CITY________________
STATE____________ ZIP______



Excellent Dealership Opportunities

- 20-Minute Training
- No License Required
- Over 5,000 Powered Parachutes Flying
- Spotless Safety Record
- From Land, Ice, Or Snow
- Nothing Easier, Safer, Or More Fun!!!

PARASCENDER

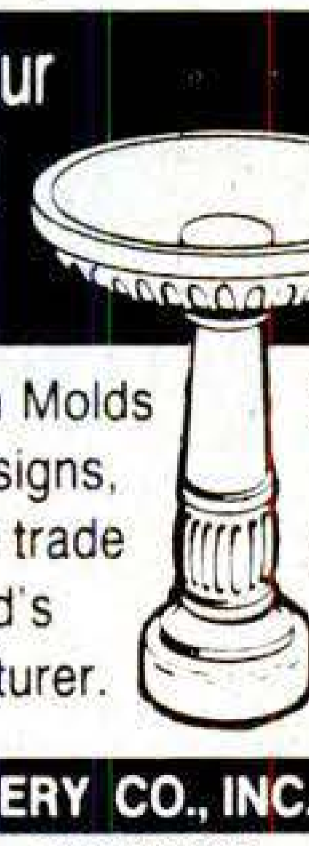
Man's oldest dream come true! Yearround family fun! You have to see this craft to believe it. Fascinating video with complete information on the safest most unique aircraft ever conceived by man. Destined to be the hottest selling aircraft in the world. Video in VHS, Beta or PAL. Add $10 for Beta, $20 for PAL. Add $2 S/H for Canadian, $10 Foreign, U.S. Funds Only. WA State, add 7.5%. Send check, money order or call for COD (U.S. only).

POWERED PARACHUTES
POWERCRAFT CORP.
formerly Paracraft Corp.

Info Pack	$ 1
Dealer Info Pack	$ 3
Video and Info Pack	$21
Video and Dealer Info Pack	$23

513 N. 21st. Avenue, Suite C Dept. PS
Yakima, WA 98902-1843 TEL: 509-457-7641 FAX: 509-457-0792

Make and Sell Your Own Ornamental Concrete Items!



Book about Aluminum Molds including over 425 designs, prices and production trade secrets from the world's largest mold manufacturer.

Book only $10

CONCRETE MACHINERY CO., INC.
P.O. Box S99, Hickory, NC 28603

Classified Opportunity Mart

Reach 4.4 million readers every month with an ad in Popular Science's Classified Opportunity Mart. **October Issue Deadline** (on sale September 11) is **July 23**. Rates: $10.50 per word. Min. ad 10 words. Darker type (**Bold**) words $1.00 per word extra. Display Classified: $585 per inch. Payment with order, or charge your Visa, MC, Amer. Exp., or Diners Club Account (give # & exp.) Advertisers using box number in ad must furnish name & street address for our records. Send order & remittance payable to POPULAR SCIENCE, Classified Dept. 6C, 2 Park Avenue, New York, NY 10016, 212-779-5163. For advertising information call **800-445-2714. Fax #: 212-779-5568.**

Dorothy Ellis, Classified Advertising

CABLE TV DESCRAMBLERS

JERROLD	$105.00	ZENITH SUPER	
TRIMODE	$119.00	SSAVI...........	$225.00
HAMLIN	$102.00	TOCOM..........	$319.00
SCIENTIFIC-		EAGLE...........	$119.00
ATLANTA	$140.00	COPY GUARD	$59.95
OAK M35B	$99.00	STARGATE....	$99.00
ZENITH	$185.00		

MANY MORE... CALL OR WRITE FOR FREE FAST INFORMATION.

YOUR BEST BUY'S & WARRANTIES FOR CABLE CONVERTERS AND DESCRAMBLERS START WITH A FREE CATALOG FROM:

M.D. ELECTRONICS INC.
115 NEW YORK MALL
SUITE 133-S3
OMAHA, NE 68114

ORDERS AND CATALOGS CALL
TOLL FREE
1-800-624-1150

Mastercard C.O.D VISA

FOR INFORMATION PLEASE CALL
(402)554-0417

BY ORDERING CABLE TV EQUIPMENT FROM M.D. ELECTRONICS THE PURCHASER AGREES TO COMPLY WITH ALL STATE AND FEDERAL LAWS REGARDING PRIVATE OWNERSHIP OF CABLE TV EQUIPMENT. IF YOU ARE UNSURE OF THESE LAWS CHECK WITH YOUR LOCAL OFFICIALS.

STOP JAMMIMG ME

If you rent video tapes they're jamming you too.

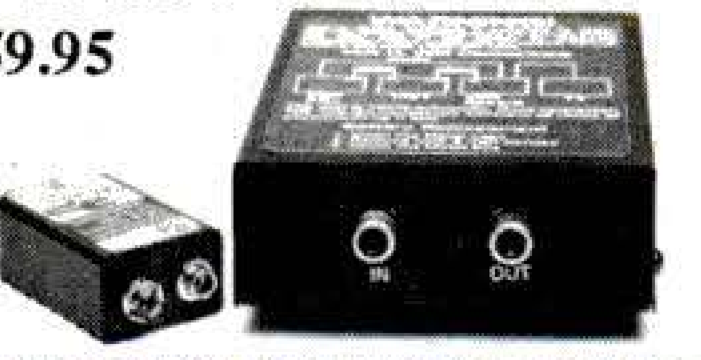
When playing back rented **movies you** will notice annoying **flashes, streaks, jitters ect. This is caused** by **copy protection jamming embedded in the** video. The **Video-2010 will spot and completely** eliminate Macrovision **and all current copy protection and** jamming **giving you a crystal clear picture.**

Guaranteed eliminates all copy protection

- *Completely automatic no adjustments.
- ***Digital state of the art.**
- ***Works on all TV's, VCR's, Beta, Cable.**

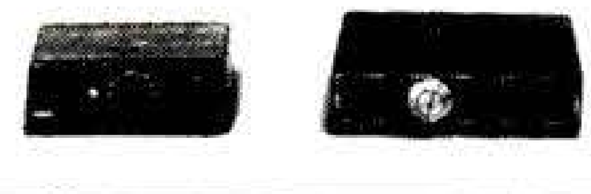
MC Order toll free VISA
1-800-624-1150

$59.95



**Call or write for your free catalog
402-554-0383
Everquest Corp. 875 So.72nd**
Omaha, Ne. 68114

CABLE TV DESCRAMBLERS!



BARGAIN HEADQUARTERS!

**•JERROLD™ •TOCOM •HAMLIN
•OAK •ZENITH •SCIENTIFIC
ATLANTA
6 month warranty! We ship C.O.D.!
Lowest retail/wholesale prices!
FREE CATALOG:
Global Cable Network
1032 Irving St. Suite 109
S.F., CA 94122
NO CALIFORNIA SALES!!!**

ORDER TODAY! 800-327-8544

HUNTING-BOWFISHING-TARGET-SURVIVAL-BIGGAME WEAPON-DEER-ELK-BOAR

BLACKHAWK® SUPERBOW® ~~$199~~ $79.95 EA.

ARCHERY WORLD USA — USA MADE

2 FOR $69.95 EA.
ADD $8.90 UPS EA.

150 lb. Crossbow, laminated heat-cured suspension fiberglass bow, Fiberite® glass stock, die-cast alloy nose, front/rear Steel micro-adj. sites, wind/elev, failsafe trigger, safety, brass track, ckr'd grips, MonteCarlo cheekpc, scope mt, T-stirrup, recoil pad, 110 yds 225 fps.

ALL ITEMS 40-70% OFF

Fish attach/harpoon	$12.75
Cocking lever (opt)	$18.75
Camo padded sling	$8.75
Camo X-Bow case	$25.75
Camo Quiver	$9.75
Bow strings	$5.

1-DAY SHIPPING
VISA, MC
AmX,
Send
Check, M.O.

Pos. legal 50 states
Must be 18

Nikko® Crossbow Scopes
4x20(sml) ~~$39~~ $22.22
4x32 (big) ~~$89~~ $44.44

Easton alum. arrows per Doz:
16" Target points ~~$39.95~~ $23.75
16" Hunting Broadhead ~~$59.95~~ $35.75

7-day Satis. Gtd. NO COD **ORDER NOW! WE'LL SHIP TODAY!**

BLACKHAWK CALL 800-228-2323 or 801-975-0222
CROSSBOWS, INC. BOX 27222-P Salt Lake City, UT 84127

AUTOMOBILES

BUILD A BIKECAR
The Amazing Mini Car You Can Build with Bicycle Parts!
Electric Motor and Pedal Powered!
Fun to Drive!
Easy to Build!
PLANS $9.95
Satisfaction Guaranteed or Your Money Back

SEND TO:
BIKECAR CORP.
P.O. Box 7077S,
Endicott, NY 13760

GOVERNMENT SEIZED Vehicles from $100. Fords. Mercedes. Corvettes. Chevys. Surplus. Buyers Guide (1) 805-687-6000 Ext. S-20025.

$225 DAILY "CHROME PLATING" AUTO PARTS, MOTORCYCLES, INEXPENSIVE, EASY, (FREE) information: Chrome, Box 2285S, Waldorf, Maryland 20604.

ATTENTION !! Hobbiests, Handymen, And Do-It-Yourselfers.....

CHAMPION • GOLD

AIR-BRUSH KIT

FREE AIR-PROPEL CAN

NEW SERIES

ACT NOW $ 19.50 !!

- **TOUCH UPS**
- houses
- boats
- planes
- autos
- ceramics
- models
- **ETC...**

These Kits Include: Fine head air brush, 5 ft. Hose, 2 oz. jar with lid, 3/4 oz. jar, propel regulator and wrench. These kits will **NOT** be offered at dealers cost again! **SO ACT NOW** send $19.50 plus $4.50 to ensure shipping and handling to: **HK Commodities,** 2827 Broadwell Dr., Raleigh, N.C. 27606.

VAPOR Carburetor Triples MPG. Free Information. H&A, R2PS, Bowling Green, MO 63334.

TIRE WEAR REPORT - Compare. $ave. Send $10; Information Services, P.O. Box 326, Shrub Oak, NY 10588.

GOV'T AUCTIONS Listings for Auctions in Northeast Region Only. Send $10 to: Affordable Gifts. PO Box 2427 Secaucus, NJ 07094.

SAVE to **50%** on Gasoline and Car Expenses. **500** Timely Tips. $6.00. Premier International, 21645 Marydee Ct., Hayward CA 94541.

IS It True Jeeps for $44 through the Government? Call for facts! 1-708-742-1142 Ext. 4606.

DRUG RAID SEIZURES! Buy Dirt Cheap. Mercedes, Fords, Porsches, vans, Trucks: Write: Seizures: Box 4309-YA, West Covina, CA 91791.

STOP FROM BEING RIPPED OFF! Do's and Don'ts of Buying a Used Auto/Truck. $4.00. ECU, Dept PS08B. P.O. Box 789 Deer Park, NY 11729

G.S.T. GAS SAVING TECHNOLOGY. Two Cycle Diesel Cars, Motor Homes. Send $3.00 Room #Two, South P.O. Box 3319, Athabasca, Alberta Canada T0G 0B0.

AUTO SUPPLIES & EQUIPMENT

ENGINE OVERHAUL KITS: Wholesale Catalog $2.00. Engine Service Group, Dept. PS, Box 13053. Lansing, MI 48901.

SLICK 50, WE WILL BEAT ANY PRICE! U.S. AUTO-TECH, 1-800-227-5425. FREE CATALOGUE!

AS SEEN ON T.V! - GLO SHIELD/GLASS SHIELD Automotive, Boat, Household care products. Saves You Time and Money! Easy to use! 2,000,000 Satisfied Customers! 3 year Guarantee! Catalogue $2.00. 40 Wall St., suite 2124, New York, N.Y. 10005.

FIRE EXTINGUISHERS

OUR INFORMATION PACKAGE WILL TELL YOU WHAT TYPE OF FIRE EXTINGUISHER TO USE ON YOUR HOME, AUTO, BUSINESS, PLANE, BOAT. CO2? HALON? DRY CHEMICAL? INDUSTRIAL GRADE AT DISCOUNT PRICES!!! SIMPLY SEND $2 (REFUNDABLE TOWARD FIRST ORDER) FOR INFORMATION PACKAGE AND COLOR CATALOG TO:
PALM SPRINGS FIRE, P.O. BOX 1607
PALM SPRINGS, CA 92263 (619) 325-6080

AUTO GIFTS. Free Information (604)785-7078. Pleezelp Roadsigns $13.95. Blindspot Mirrors $7.95. Box 86608 North Vancouver, British Columbia V7L 4L2.

HIGHWAY AUTO EMERGENCY KIT. Get HELP quick for emergencies or stalled cars. Send $1.00 for each kit or $5 for 6 kits to: ATBX - 333 N. Michigan #528, Chicago, IL 60601.

CAR ALARMS. Simple, easy plans $5.00. Gemtec, 9300 Mansfield Road, Suite 100, Shreveport, LA 71118.

VEHICLE I.D. TAGS
Helps Vehicles Last Longer

OIL CHECK ENGINE OIL
POWER STEERING TRANS CHECK/ADD
RADIATOR COOLANT WASHER FLUID

ALL DRIVERS find maintenance locations FAST-EASY-SURE with these UNIQUE YELLOW TAGS attached by special TIES to existing wires, cables or hoses in engine compartment of CAR-TRUCK-VAN-BUS & etc. at these 8 points. Copyright © 1990 VPC—All rights reserved. Set of 8 TAGS, TIES & Instructions $4.50, two for $8.00, SAVE-three for $10.00. No COD's. V. Price Co., P.O. Box 3, Brazil, IN 47834.

BE SAFER!!! 81% BRIGHTER hig beams, same headlights/voltage! K $22.95. Turn signal **REMINDER!** K $14.75. PLANS ALONE $5.95 each. Shar en lawnmower easily, **WITHOUT** removi blades! DETAILS $5.00. BiStar, Box 122 Manassas, VA 22110.

SLICK 50 & FREE ARMO ALL!*
CALL RADAR WORLD *WITH PURCHAS
1-800-237-2897 MONEY BACK GUARANTE
BEL, UNIDEN, COBRA, SPECTRU
210 S. MILWAUKEE, WHEELING, IL 6009
WE WILL MEET ANY PRICE! CALL 24 HRS.

AIR CONDITIONING

AIR Conditioning And Heating Equi ment, parts, supplies, Wholesale to yo 1-800-SAY-AIR-1.

BETTER HEALTH

LEARN HOW to **REDUCE STRES** Send $7.50 to: HH Consults, P.O. Box 9 Texarkana, Arkansas 75504

DON'T TRUST tap, filtered or bottl water! Be Sure. Purify your own for penni Only $14.95. Money back guarantee. Inn vations Unlimited, Box 3747, Carson Ci Nevada 89702.

MUSCULAR CUISINE are you tired the way you look and feel. Delicious recip from top athletes around the world. Bo energy and stamina. Recipe book, $5.00. Enterprises, R.T. 3, Box 61, Dallas, N 28034.

KILL FIREANTS! Environment Sa Non-Toxic! Home products! Report $3. M. Clark, PO Box 4507, Federal Way, W 98063.

NECK Pain, Headaches, Arthritis, Wh lash, Arm Numbness, helped by the **CO FORT CRADLE** Orthopedic Pillow. $39 Postpaid. Doctor's Clinic, 110 Chestnut, M flinburg, PA 17844.

BOATS, INBOARD & OUTBOAR MOTORS

BOAT KITS—PLANS—PATTERNS CHOOSE FROM HUGE SELECTION 8'/70' — Powerboats — Sailboats Houseboats — Rowboats — Hydroplanes Tunnelhulls — Duckboats — Canoes Kayaks — Dinghies — SUPPLIES Epoxies — Fiberglass — Foam — **SE FOR GIANT ILLUSTRATED CATAL** $3.00 ($5.00 airmail) —Book "Amate Boatbuilding" $6.00—**CLARKCRAFT** S Aqualane, Tonawanda NY 14150.

EVINRUDE—OTHER BRANDS 19 BARGAINS . . . All Sizes . . . $2.00 Ha dling. Scott McCulloch parts . . . Electra M rine, 610 Merrick Road, Lynbrook, N York 11563. (516)599-3003.

WATERBUG! Sport/Bass/Personal W tercraft. Easily built, transportable. Lu beryard materials. **UNDER $60.** Ph plans $20. Bluemax Box 456, Wichita Fa Texas 76307.

ALTERNATE ENERGY

FREE ENERGY! Fuel-less Motors a Generators! H&A. R2EPS, Bowling Gre MO 63334.

THE GREAT DOVRE HOT STO SALE. **$100 INSTANT DISCOUNT** wh you present this ad at store and buy a Do Horizon or Heirloom HC wood stove 11/15/90. For nearest dealer, **CALL 1-8 DOVRE US.** (8/PS)

ALTERNATE ENERGY (Con't)

SOLAR CELLS

If **you** want Solar Electricity at the **Very Best Prices,** send $2 (Refundable) for our catalog of **New & Surplus** Solar Electric **panels**, cells, inverters, controllers, books, and related technology for independent power.

APPLIED PHOTOVOLTAICS
Box 2773, Staunton, VA 24401
"Bringing the cost of Solar Electricity down to earth."

ENERGY, TELSA COILS, ANTI-GRAVITY, UFO'S PARANORMAL PHENOMENA Information Package—$5.00—HEER, P.O. Box 5286, Springfield, VA 22150.

200 SUPPRESSED/DORMANT INVENTIONS! RARE INFORMATION DATABASE CATALOG! $2. REXCO, Box 19250, Jean NV 89019.

LAYMAN'S GUIDE TO UNDERSTAND AND INSTALL YOUR OWN GROUND SOURCE HEAT PUMP. $19.00 A.B. &E. Blair, OK 73526.

SOLAR collectors you construct. Send stamp. 10909-PS Hayvenhurst, Granada Hills, CA 91344

120VAC from 12/24/48VDC. Build/Buy, Info $2.00 Airwave 3528 E. Grant, Tucson AZ 85716.

$70,000 FREE Development Grant each energy innovation $12.00 pamphlet includes application. **INNOVENT,** 7305 Kingsridge, Oklahoma City, OK 73132.

CONVERT 12VDC INTO 120VAC. Build **INVERTERS** using common, inexpensive parts! Practical, detailed **NEW** booklet. Send $7.95 to: Stan Freeman, 369 Zandecky, Chehalis, WA 98532.

PORTABLE ELECTRICAL POWER Low Cost To Build - Complete Illustrated Plans - $5.00. **NIEMANS POWER SYSTEMS,** P.O. Box 473, Angwin, CA 94508.

BUILD solar/wind powered firewood dehydrator. Attractive, Easy to build $9.95. Winslr, P.O. Box 86, Hesperia, MI 49421.

ARTS & CRAFTS

"GETTING Started In Stained Glass" $1.00. Whittemore, Box 2065X, Hanover, MA 02339.

POTTERS WHEEL Build your own. Complete plans $5.00, Miguel Mirabal, RT 1 Box 1540, Las Vegas, N.M. 87701

HAVE MORE FUN WHEN YOU TURN OUT THE LIGHTS Transform plain space into blue spectrum black light fun with new paint process. For 8 oz. Send $14.95 plus $4.00 S/H to: Chromalight, Dept 124 2316 Delaware Ave, Buffalo NY 14216.

NEON ART HOME STUDY COURSE. **FREE DETAILS.** Neon, 522 Myrtle, Dept. PS80 Arlington, TX 76018.

ALL TERRAIN VEHICLES

(21-years-old and over, Please)

Call Toll-Free 1-800-255-2511
(From anywhere in the U.S. or Canada)

Recreatives Industries, Inc.
60 Depot Street, Buffalo, NY 14206

AGENTS WANTED

122% PROFIT. Meet Big Demand For Relief from driving fatigue, stress, pain! New woodbeaded Massage Cushion. Free information. 800-999-1089

ASTRONAUTICS

LARGE ROCKET Kits, Motors. $1.00. HSR, Box 5127, Reno, NV 89513.

BUILD YOUR OWN ROCKET MOTORS!

- UP TO 80 POUNDS THRUST!
- USING SIMPLE MATERIALS!
- FOR JUST PENNIES APIECE!

Homemade rockets go together quickly. Use homemade fertilizer/charcoal fuel. Models fly thousands of feet! Speeds to MACH 1!

Write for our catalogue, and we'll send you a working sample of a homemade electric rocket igniter AND teach you how to make your own homemade rocket motor casings, all using materials you'll find around your house.

SEND $2.00 TO:
Dept. PS8, THE TELEFLITE CORPORATION, 11620 Kitching, Moreno Valley, CA 92387

30 ANTIGRAVITY METHODS! Amazing Catalog: Send $2.00. Rexco, Box 19250, Jean, NV 89019.

BUSINESS OPPORTUNITIES

$1000's WEEKLY. Free information. Stamped envelope: Progress, Box 93248, Los Angeles, CA 90093.

$1804 MONTHLY! Buy/sell cars (spare-time). Revealing proof! Write: CODEX, 507 Oak Drive, Friendswood, TX 77546.

TAKE PICTURES for profit. Camera Ventures, Box 771, Lamara, CO 81052.

MILLIONAIRE Mailorder Expert Reveals Money-Making Secrets. Free, exciting hour cassette: Melvyn Powers, No. Hollywood, California 91609.

HYDRAULIC JACK REPAIR MANUAL AND CATALOG $10.00. HYDRAULIC PARTS SUPPLY, BOX 4157, BROWNSVILLE, TX 78523-4157.

$225 DAILY "CHROME PLATING" AUTO PARTS, MOTORCYCLES, INEXPENSIVE, EASY, **(FREE)** information: Chrome, Box 2285S, Waldorf, Maryland 20604.

MAKE $7,000 monthly as Loan Broker without investment/experience. Financial, Box 3578-Y, Anaheim, CA 92803.

$500 WEEKLY mailing ads. Admailers Associates. Box 51063, Durham, NC 27712.

MECHANICALLY inclined individuals desiring High Weekly Profits operating Small Manufacturing business Without Investment write: Businesses-P, Box 9008, Baldwin N.Y. 11510-9008.

PIANO TUNING PAYS: Learn with approved home study course, Diploma granted. American Tuning School, 17050 Telfer Dr., Morgan Hill, CA 95037.

RECONDITION BATTERIES. Easily Earn Hundreds Weekly. Untold Secrets. Free Information. Battery Outlet, Box 3300-S, Hickory, NC 28603.

$10,000 MONTHLY Taking Photographs at Home! Call recorded message: (303) 674-8155.

RECYCLE METALS, NO, NOT BEER CANS! Easy $458 weekly! Free information, Hornsby's, Box 1214, Franklin, TN 37065-1214.

$392.00 FROM Square Foot Plywood Huge Demand! Revealing Proof $1.00 (Refundable). Woodwins, Bridgewater, Mass 02324-2299.

$15,000 MONTHLY Income! Easy Moneymaking Plan. No Investment. McDowell, Box 5529-Y, Diamond Bar, CA 91765.

NEED MONEY? Free Grants, Signature Loans, Business Loans. Write: Action #7-Y, Box 5499, Diamond Bar, CA 91765.

PROFITABLE Gold Foil Printer. Personalize business cards, pencils, matches. Free details, Gold, P.O. Box 24986 (LLC), Tampa, FL 33623.

BUMPERSTICKER PRINTER. Cheap, simple, portable. Free details. Bumper, P.O. Box 22791 (LLC), Tampa, FL 33622

FORMICA: Repair Burned and Damaged Countertops **WITHOUT REPLACEMENT!** Quick, easy to $600/day. Change countertop Colors **WITHOUT REMODELING!** Millions of apartments, homes pay profits immediately. Introductory package **FREE!** 206/256-9742. Introductory Videotape $14. **RENEW-ALL** BOX 9900-SS, Vancouver, WA 98668.

PIANO Tuning Academy, 12717S Germainia, Alexander, AR 72002. Profitable, Master. Visa.

MAKE HOMEMADE BOOKLETS. I'VE EARNED $187,000 **WITH MINE. MONEY NEVER STOPS!** Free information: Dasher, P.O. Box 5320, Sevierville TN 37864.

LET THE GOVERNMENT FINANCE your small business. Grants/loans to $500,000. Free recorded message: 707-448-0270. (JG6)

$40,000 ON 1/3 ACRE! New hydroponics - inexpensive, pleasant, practical! Free information. Planter's, Box 1214, Franklin, TN 37065-1214.

ADVERTISE free in 550 Magazines. $5.00. Directory, Box 11W, Atlanta, GA 30301.

MAKE YOUR DREAM COME TRUE. EARN $60,000 YEARLY REPAIRING SMALL CRACKS IN WINDSHIELDS NOT REPLACING THEM. CALL TOLL FREE 1 (800) 826-8523 U.S./CANADA OR WRITE: GLASS MECHANIX INC., 10170 NW 47 ST., SUNRISE, FL 33351.

EARN $60 HOUR

Fix VCRs, no previous experience. All you need are small handtools and our trouble shooting guide. Work at home full time or part time. For information write:

N.E.C. COMPANY
P O Box 3043-X • Skokie, IL 60076
Call: 1-708-674-7888

PROFITABLE HOME BUSINESSES. Free details. R&S Publishing, P.O. Box 720388, Dept. B, Houston, Texas 77272-0388.

MAKE Rubber Stamps. Highly Profitable Business. Free Details. Stamper, POB 22809 (LLC), Tampa, FL 33622.

$200 $500 weekly- **AT HOME!!** No gimmicks - Details **FREE!!** Homeworkers-S, Box 32397, Palm Beach Gardens, FL 33420.

GET RICH!! Secret law smashes debts—brings cash credit! Details **FREE!!** Wealth-Kit-S, Box 32398, Palm Beach Gardens, FL 33420.

FREE SAMPLE! Miracle Polishing Cloth. 592% profit plan! R&S, 1312-PS Washington, St. Louis, MO 63103. (314) 241-8464.

$58,000.00 YEARLY MAKING BOOKLETS. 25 - STEP METHOD Shows How! Premier, Box 544 Fox Lake, IL 60020.

HOME Assembly Work Available! Guaranteed Easy Money! Free Details! Homework-PS, Box 520, Danville, NH 03819

MONEY-MAKING REPORTS: 70 Hottest Reports Available! Free Details, ERB Publications, Dept. PS8, 4705 Houghton, Fort Worth, TX 76107.

CASH IN BIGTIME on Recycling! For 10 page guide to EZ Money send $2 to: SB&S Information, P.O. Box 731, Bedford, TX 76022.

START your own business for just pennies Experience unnecessary. Send **FREE** no risk examination. **JAS** Box 2859, Big Bear Lake, California 92315

SPARE Time Fortune in Vinyl Repair. Huge demand. Exceptional profits. Everything supplied. Details free. VIP, 2036 Montrose, Chicago 60618.

T-SHIRT PRINTING MACHINES. We manufacture professional single and multi-color screen printing equipment. Inexpensive, Free Brochures. Catco, 12201PS NW 35 St., #538, Coral Springs, FL 33065.

BE your own boss! 1001 fast, easy ways to make money! Free! Rush name, address. Money Making, Dept. PS, Box Z, Studio City, CA 91614.

MAILORDER OPPORTUNITY: Start profitable home business without experience or capital. Free book. Mail Order Associates, Dept. 655, Montvale, NJ 07645.

ALUMINUM SCRAP—Recycle Yourself **—MAKE UP TO $25.00/POUND! FREE** Information: Industrial - PS890, Box 127, Alexandria Bay, New York, 13607.

PROVEN Success since 1986! Multilevel Information Hotline, Free Recording 915-366-6951.

$15,000 MONTHLY income at home! Simple! Free details! Macpress, Box 163-S, Birdsboro, PA 19508.

BECOME WEALTHY! Step-by-step Manual. **PROVEN** to make YOU money. **GUARANTEED!** Free Details! MA Publishing, 2030 SE 19 ST, Pompano Beach, FL 33062.

HIRE YOURSELF. Write SPANNCO P.O. Box 372549, Decatur, GA 30037.

START A MILLION dollar mail order business. We drop-ship 2955 best selling products. Lowest below wholesale prices. Immediate delivery. Spectacular home business opportunity. FREE BOOK. SMC, 9401 De Soto Ave, Dept. 28-20, Chatsworth, CA. 91311-4991.

COMPLETE FABRICATOR'S MANUAL **CORIAN - FOUNTAINHEAD - AVONITE** $11.95. SOLID SURFACES, Box 457, Greenland, NH 03840.

A MILLION USERS! Typewriter + Printer Ribbon Re-inker (Details) $4.00. SASE, PO Box 59174, Jackson MS 39284. (For) Canada: Heinz 2354 Longlake, Sudbury Ontario P3C-5H5.

ADVERTISE FREE in 2,300 Magazines, Newspapers, Radio, Television. $5.95: Directory, Box 14107DB, Jackson, MS 39236.

FREE, 85 MONEY Making Reports, with Reprint Rights, Order, **BERRIGER** 211 South State College, Suite 169G, Anaheim, CA 92806.

OPPORTUNITY SEEKERS. Receive hundreds of offers. Send Name, address and $2.00 to: MEMORY LANE, Box 686, Newington, VA 22122.

MAKE MONEY AT HOME! Easy. Free Information: Falcon. Box 408-R8, Long Beach CA 90801.

ENTREPRENEURS - Unlimited income: Six months from now you will wish you had called this number: 213-856-8985 Recorded message.

$1000'S WEEKLY Processing Mail! Start immediately, Free supplies/postage. No experience, no obligation. Rush Stamped envelope, Macpress, Box 163M, Birdsboro, PA 19508.

SAVE TIME & MONEY Your name and address forwarded to hundreds of dealers for a one time fee of $2.00. WJS, Box 8316, Alexandria, VA 22306.

IMPORT-EXPORT opportunity, profitable world-wide, mail order business from home, without capital. We ship plan for no risk examination. Experience unnecessary. Free Report. Mellinger, Dept. A2699, Woodland Hills, California 91367.

BECOME A PROPERTY MANAGER. Home study course. Learn rental and commercial property business. Free Literature. 800-223-4542 DEPT. MJ109.

GET RICH! Amazing plan brings $3345 in 21 days. Write: Omega: Box 4309-YS, West Covina, CA 91791.

START your own business. Easy! Profitable! Little or no capital needed!! Free details. Business Success +, Box 152J, Greendale, WI 53129.

FASTEST LEGAL WAY TO MAKE MONEY $50 billion industry. All the details you need to acquire **FINANCIAL SECURITY** in the 90's. **NO GIMMICKS. NO RISK.** $uccess or money back! Invest $12.95 today. MLB Publishing, P.O. Box 4828C Regina, SK S4P 3Y4.

EARN BIG MONEY!
FANTASTIC OFFER!
WRITE simple sentences. **TEN** lesson course. **EASY** proven methods. $9.95 Refundable, **LANGES** Enterprises Dept. PS-8, 10 Shelly Rd., Norton, MA 02766.

CREDIT AND CASH PROBLEMS stopping you from owning your own home? Send S.A.S.E., BISES INFO Co., P.O. Box 25045, Phila., PA 19147.

SAVE THOUSANDS ON HOME MORTGAGE. NO REFINANCING, SET-UP FEES, BIWEEKLY PAYMENTS, EXCELLENT BUSINESS OPPORTUNITY. $1.00 (REFUNDABLE) R.L.S. ASSOCIATES, BOX 47349, JACKSONVILLE, FL 32247-7349.

BECOME A REAL ESTATE APPRAISER. $100,000 PLUS POTENTIAL. HOME STUDY. EARN PROFESSIONAL CERTIFICATION. FREE LITERATURE. 800-223-4542 DEPT. RJ109.

BUSINESS OPPORTUNITIES (Con't)

BE YOUR OWN BOSS! Earn Unlimited Income! Assemble Products At Home: Electronics, Crafts, Others. No Experience Needed. Call 1-504-641-7778 Ext. 8328. Open 24 Hours, Including Sunday.

DRUG RAID SEIZURES! Buy dirt cheap. Cars, houses, boats, computers, furniture. Write: Seizure: Box 4309-YD West Covina, CA 91791.

GAIN FINANCIAL REWARDS. EVERYONE HAS THIS ABILITY. AMAZING NEW BOOKLET TELLS HOW. Send $8.00 to Opportunities Plus. P.O. Box 176, Milton, DE 19968.

REVOLUTIONARY Tax Receipt Keeping System. No Competition. Sample/Business Kit $3.00. UKAREX, 191-35PS Harder, Hayward, CA 94544.

READ BOOKS for pay! Call 1-900-847-7700 ($0.99/min) or Write: PASE-VX9, 161 Lincolnway, North Aurora, IL 60542

TIRED OF WORKING FOR OTHERS? Start your own business. Easy to follow business reports. A and S Enterprises. Dept. 107, Box 94863, Pasadena, CA 91109.

MAKE $25,000 MONTHLY. Simple step by step instructions. Free Details. Gallagher Publishing, 820 Arthur Ave. Suite 1A, Oceanside CA. 92056.

MAKE $50/HR WORKING EVENINGS OR WEEKENDS in your own electronics business. Send for free facts, MJES INDUSTRY, Box 531, Bronx, NY 10461-0208.

FANTASTIC Money-Maker Details: $1.00 and Stamped Envelope. 135 W. Nuevo, Ste-B-221, Perris, CA 92370.

PROFITABLE ECOLOGY works now! Environmental Businesses Report 1990's $5.95. Ecomerican, Box 1371, Valdosta, GA 31603-1371.

NEW! GROW EXPENSIVE PLANTS. SELL FOR 2,000% PROFIT. Free information. GROWBIZ, Box 306-S8. Seminary, MS 39479.

RECEIVE All Free Ads In This Magazine. **SAVE MONEY AND TIME** Send $2.00 To: Stott, Box 714, Swanton VT 05488.

USE Your Knowledge. Write Instruction Manuals For Profit. Information Free. Great American Publications, Box 10422, St. Petersburg, FL 33733.

$58,000 YEARLY MAKING BOOKLETS. 25 - STEP METHOD shows how! Premier, Box 544, Fox Lake, IL 60020.

MAKE $50,000 in 90 days. Proven, legal business opportunity. Free information. Spyre Enterprises. Dept. PS1, 450 Eldorado Parkway, Cape Coral, FL 33904.

GET RICH AT HOME! Make your fortune selling homemade booklets by mail. Complete get-started manual reveals how. Only $5.95: Fineline Publishing, Box 2211, Sandusky, OH 44871.

UNLIMITED INCOME Operating Home Business. Free Details. Rush Stamped Addressed Envelope: Success Unlimited, Box 462-P, Fairfield, CA 94533

56,731 "FOREIGN TRADE" CATALOGS. DIRECTORY guide. Sources for Everything! 32 Countries. $5.95: Catalogs, Box 14107FB, Jackson, MS 39236.

HIGH PROFIT, NO INVESTMENT, MONUMENT DEALER, YOUR AREA KIT $25.00 (REFUNDABLE), GRANITE INDUSTRIES, P.O. BX. 504 ELLIJAY, GA. 30540.

GET PAID for mailing letters! Write: PAASE—WF5, 161 Lincolnway, North Aurora, IL 60542.

BIRDS & ANIMALS

BIRD LOVERS Attract Goldfinches. Unique nesting product, Fully assembled $5.95, Havegard Farm, 225 Navarino, Algoma, WI 54201.

BURGLAR—FIRE ALARMS

BRIGHT Lite-Blasting Shreik Burglar Alarms $9.95 + $2.00 Shipping. Carry Everywhere For Instant Protection. Send Cheque Or Money Order. T&L Enterprises, 7305 Woodbine Ave., Dept 536, Markham, Ontario L3R 3V7.

BOOKS—MAGAZINES

PUBLISH YOUR BOOK! Join our successful authors. All subjects invited. Publicity, advertising, beautiful books. Send for fact-filled booklet and free manuscript report. Carlton Press, Dept. PSU 11 West 32 Street, New York 10001

MANUSCRIPTS Wanted, all types. Publisher with 70-year tradition. 1-800-695-9599.

EARN Your Own Fortune In Mail Order! Easy Step By Step Guide Shows How. $9.95. Lifestyle, Dept-8S, P.O. Box 841, Little Falls, NY 13365.

AVIATION

BOOMERANGS . . . INCREDIBLE RETURNS! World's Best Hi-Tech Designs. Free Illustrated Catalog. Amazing! **BoomerangMan,** 1806-2 N. 3rd, Monroe, LA 71201-4222.

HOBBY HELICOPTER Ultralight True Helicopter-Conventional Helicopter controls. Simplified construction—Motorcycle or Rotax engine. Information: $5.00: **POLYNOVA,** Dept. PS, Saint-Remi, Quebec Canada J0L 2L0.

BUILD YOUR OWN **HELICOPTER!**

Take-off from your backyard to open-sky adventure!

- Simple, low-cost assembly
- May be flown without a license
- Several helicopter & gyrocopter kits & plans available

Helicopter Plans	$14.95
Helicopter Experimenter Book . . .	$11.95
Complete Kit Info.	$10.00

SPECIAL! All 3 items: Only $19.95

(FOREIGN: add $4 U.S.)

HELICRAFT

P.O. Box 50-A
Riderwood, MD 21139
Credit card order line: 1-301-583-6366

HOMEBUILT HELICOPTERS

New Designs

7 Models Available

- HOVERCRAFT
- GIRO KOPTER
- JET TIP HELICOPTER
- CO-AXIAL HELICOPTER
- FULL FLIGHT HELICOPTER

PLANS KITS

INFORMATION PACK $5.00
Includes: specs, photos, prices

BW ROTOR CO., INC.

Box 391-A
Towanda, KS 67144

MEET MANX™

YOUR PERSONAL FLYING MACHINE

Finally, an inexpensive homebuilt helicopter... **that makes sense!** Forget everything you know about conventional helicopters. We have re-written the book on helicopter design.
The **MANX**™ co-axial helicopter needs no tail rotor because it produces no torque. Twin counter-rotating rotors provide fail-safe hover and cruise flight with no noticeable vibration

- ☐ **VERY EASY & SAFE TO FLY**
- ☐ **INEXPENSIVE TO OPERATE & MAINTAIN**
- ☐ **2 PASSENGERS @ 150 MPH; 600 MILE RANGE**
- ☐ **USES AUTO FUEL: OVER 20 CU. FT. BAGGAGE**

Learn more about the remarkable MANX™ **co-axial helicopter.**
Send today for free Mini-Information package
Enclose $2.00 (Non-U.S. enclose $4.00) for postage and handling: or

Order the following Manx products:

☐ COMPLETE INFO PACK + 3 VIEW DRAWINGS	$20.00
☐ TECHNICAL REPORT (must reading)	$30.00
☐ VHS VIDEO TAPE OF MANNED PROTOTYPE **IN ACTUAL FLIGHT TEST**	$40.00
☐ ORDER ALL (3) ITEMS (SAVE $15.00)	$75.00

Please send cash, check or money order (in U.S. funds drawn on a U.S bank only). No COD's. Non-U.S. add $7.00 postage.

Moshier Technologies
334 State Street, Suite 106, (Dept. PS3), Los Altos, CA 94022

Build this Sidewalk Flyer

- Full size blueprints & assembly manual $20
- Complete & partial kits available
- Pedal operated
- Send $1 for catalog
- 4 Models to choose from
- Instant Collectors Item

Wings & Wheels for kids of all ages
23025 PS Sonoita
Mission Viejo CA
92691

Ultralight Helicopter

- Pilot License Not Required -

DRI Technologies

New Development!

- Off the Shelf Components
- Quick Build
- Designed as an ULTRALIGHT

Brochure: $10.00
CA Residents add 6% Tax

DRI Technologies
PO Box 5102, Dept 46, Vandenberg AFB, CA 93437

BUY IT WHOLESALE

CLOSEOUTS! Wholesale! Overruns! Freebies! Information (stamp): DDN, Box 20152-G, Ferndale, Michigan 48220.

400,000 BARGAINS Below Wholesale! Many Free! Liquidations Closeouts! . . . Job Lots . . . Single Samples. Free details. Worldwide Bargainhunters, Box 1409-B, Holland, MI 49422.

MILITARY Surplus (Wholesale) Thousands items new and used. 24-page catalog $2.00. Crazy John's Surplus 2011-B, Nooseneck Hill Road, Coventry, RI 02816.

COMPUTERS

BUILD your own Macintosh and save 50%. New book shows how. Free info. Brant's, Box 68708, Portland, OR 97268.

ATTENTION PC NOVICES. Complete Guide to purchasing and using personal computers. $6.95. Greyware Press, Box 205, Penfield, NY 14526.

LOWEST PRICES IN THE WORLD GUARANTEED! Computer Systems and Software. Send $10.00 for Super Software Collection, Free Samples and Catalog. Specify Format, ROSS COMPUTERS, Box 1502 #138, Red Bluff, CA 96080.

FREE! IBM SOFTWARE CATALOG. 2000+ Disks 1-800-345-2983 Mega-Byte Inc. pc Software Supply. 3601 Morrison Road, Denver, CO 80219

IBM WORDPROCESSOR $19. KENDA, Timberlake Branch, P.O. Box 15121, Lynchburg, VA 24502.

COLLEGE VOCABULARY COURSE. Words, definitions, complete sentences. Effective software: IBM-PC, compatibles. 256K. Hard or dual disk. 5.25". DOS 2.1 $39.95. LEARNING EDGE. PO Box 996-D, Meadville, Pa 16335.

PC BUS MOUSE EXTENSION CABLES: 8Ft. shielded, Compatible with all PC Bus mouse, trackball applications. $24.95 IDEX Co. 714/548-7574

AUTO LINE SWITCHER: operate **MODEM,** fax, answering machine and telephone from single incoming line. $219.99. Call (414) 694-8015 for order information.

CANADIAN MAIL ORDER for EVEREX products. Send for free Catalogue. to: Lorimer Designs Limited, 10434 139th Street, Edmonton, Alberta Canada T5N 2K5.

VIDEO—HOW TO BUILD YOUR OWN PC COMPATIBLE COMPUTER AND SAVE $$$. $20 ppd. 1-800-537-7932. B&J SPECIALTIES, Box 7783, San Jose, CA 95150.

CB RADIO

POLICE—FIRE SCANNERS, CB'S MARINE 2-WAY, ANTENNAS, HPR, BOX 19224PS, DENVER, CO 80219.

CABLE EQUIPMENT

CABLE TV "BOXES"

Converters—Descramblers
Remote Controls—Accessories

★ Guaranteed Best Prices ★
★ 1 Year Warranty—C.O.D.'s ★
★ Immediate Shipping ★
★ FREE CATALOG ★

Call or Write

TRANS-WORLD CABLE CO.
12062 Southwest 117th Court, Suite 126
Miami, Florida 33186
1-800-442-9333

CABLE T.V. EQUIPMENT
Why Pay a High Monthly Fee?

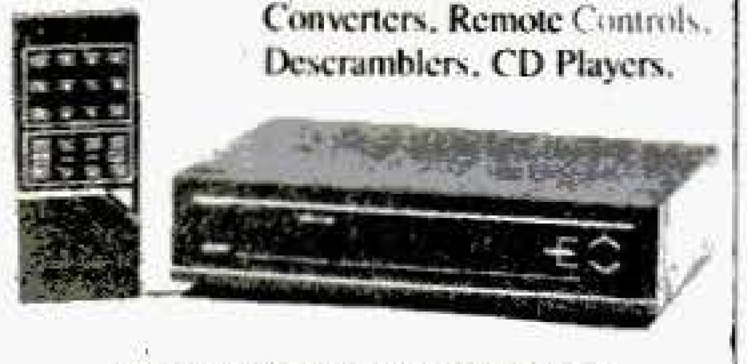
All makes and models! Low Prices. Quantity discounts. 60 Day Warranty. Shipment within 24 hours. Stamped envelope (.50¢) for FREE catalog. C.O.D. orders accepted.

L & L ELECTRONICS, INC.
1430 Miner St., Suite 522
Des Plaines, IL 60016
For Information 1-708-438-4056
Orders Only 1-800-542-8190

CABLE TV BOXES We sell only the bes low prices, we ship COD. Free Brochure. Ac Products, P.O. Box 582, Dept. S, Saco, M 04072, **1-800-234-0726.**

CABLE TV EQUIPMENT

Converters, Remote Controls, Descramblers, CD Players.



JERROLD-OAK-SCIENTIFIC
ATLANTA-HAMLIN
ZENITH MANY MORE CALL TODAY!

✓ Only quality products sold
✓ Easy to use ✓ Satisfaction guaranteed
✓ Knowledgeable sales staff
✓ Most orders shipped within 24 hours

CALL FOR YOUR FREE CATALOG

1-800-228-7404

MAKE THE CONNECTION WITH

NU-TEK ELECTRONICS

5114 Balcones Wood Dr. #307 Dept. 298
Austin, TX. 78759

CABLE TV SECRETS—the outlaw pul lication the cable companies tried to bar HBO, Movie Channel, Showtime De scramblers, Converters, etc. Suppliers lis included. $9.95. Cable Facts, Box 711-PS Pataskala, OH 43062.

MAINTAIN CABLE PRIVACY Orde Tech-Block Today! $19.95. Stage Door Vide P.O. Box 518, Belleview, FL 32620-0518

CABLE TV SECRETS Methods, de scrambler plans, suppliers, more. Immedi ate shipment! Send $3.95: HCC, P.O. Bo 27983. San Diego, CA 92128.

CABLE TV converters and descrambler liquidation! Zenith, Tocom, Hamlin, Oa Jerrold, Scientific Atlanta. Quantity dis count! Order now Visa/MC/CO 800-962-6836.

CABLE TV Converters and descrambler Bargain Headquarters! Jerrold, Tocom, Ze nith, Hamlin, Scientific Atlanta, Oak M35 Only $60. Free Catalog. GCN. 1032 Irvin ST #109, SF, CA 94122. Order Now! Visa MC/COD 800-327-8544.

CARTOONING, SIGN PAINTING

LEARN Sign Painting, Pinstriping. Fre Catalogue. Kaufmann Company, Cente town, MO 65023.

CATALOGS

GIANT Catalog of brand name offic home equipment, low discount prices sen $29.95: MAH Merchandise, P.O. Box 916 Spring Lake NC 28390.

DO-IT-YOURSELF

TELEPHONE LISTENING DEVICE

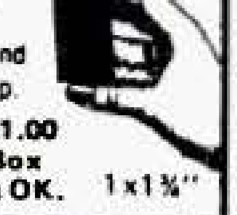
Size 1cu. in.

Record telephone conversations in your office or home. Connects between any cassette or tape recorder and your telephone line. Starts automatically when phone is answered. Records both sides of conversation. Stops recorder when phone is hung up.

$19.95 EACH Qty Disc Avail

Super Powerful FM TRANSMITTER

Many times more powerful than other transmitters. Transmits up to ¼ mile to any FM radio - Easy to Assemble Kit - up to 9V battery (not incl.)
For catalog of Transmitters, Voice Scramblers and other specialty items, enclose $2.00 to USI Corp.



1×1¾"

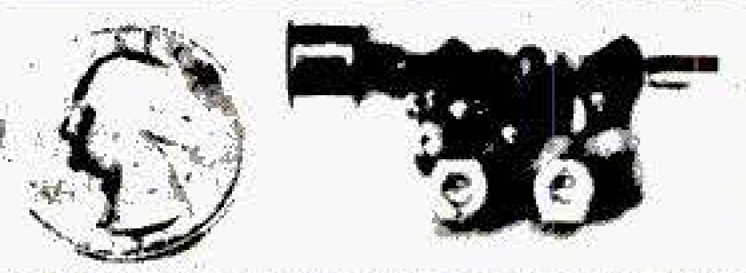
Call 407-725-1000 or send $19.95 + $1.00 shipping per item to: USI Corp., PO Box PS-2052, Melbourne, FL 32902 COD's OK.

DO-IT-YOURSELF (Con't)

SURVEILLANCE - COUNTERSURVEIL- ANCE! Guaranteed Lowest Prices! Huge atalog $5.00 (Refundable). PROTECTOR, O. Box 520294-A, Salt Lake City, UT 84152.

ARROWHEAD Making. VHS $29.95 S/H 3.50. Commons, Box 5012-PS, Central oint, OR 97502.

DETECTION—Surveillance, Debug- ng. Plans, Kits, Assembled Devices. Latest igh-Tech catalog $5. Detection Systems, 515 E. Thomas, #16-864A, Phoenix, Arizo- a 85016.



PICKS UP A WHISPER 50 FEET AWAY

The model WAT-50 miniature FM transmitter uses a 4-stage circuit NOT to be confused with a simple wireless microphone. Simply snap the unit on top of a 9V battery and you can hear every sound in an entire house up to 1 mile away! Use with any FM radio. Tunes to any requency from 70mhz—130mhz. Easy to as- semble kit includes all parts and instructions. Only $29.99 tax incl.

Call or send MO, VISA, MC for immediate de- very. Include $1.50 S&H. FREE SHIPPING on orders of 2 or more. All orders shipped by J.S. Mail. COD add $4.00. Personal checks allow 21 days.

DECO INDUSTRIES
BOX 607
BEDFORD HILLS, NY 10507
914-232-3878

NEW HE NE LASER TUBES $35

Dealer Inquiries Invited.
Free Catalog!

MEREDITH INSTRUMENTS
6403 N. 59th Ave. • Glendale, AZ 85301 • (602) 934-9387
"The Source for Laser Surplus"

QUARTZ CLOCK MOVEMENTS and pplies! Low Prices! Yankee Ingenuity, Box 3S, Altus, OK 73522.

AMAZING

SCIENTIFIC & ELECTRONIC PRODUCTS

PLANS IN STOCK

GRA1–ANTI GRAVITY GENERATOR	$10.00
LC7–40 WATT BURNING CUTTING LASER	$20.00
RUB4–HI POWER PULSED DRILLING LASER	$20.00
BTC5–1 MILLION VOLT TESLA COIL	$20.00
LLS1–LASER LIGHT SHOW 3 METHODS	$20.00
EH1–ELECTRONIC HYPNOTISM TECHNIQUES	$8.00
EML1–LOWER POWERED COIL GUN LAUNCHER	$8.00
JL3–JACOB LADDER 3 MODELS	$10.00
SD5–SEE IN THE DARK	$10.00
LEV1–LEVITATION DEVICE	$10.00

KITS PROGRAM AVAILABLE

FMV1K–3 MILE FM VOICE TRANSMITTER	$34.50
HVM7K–HIGH POTENTIAL GENERATOR	$129.50
NIG9K–HI FLUX NEGATIVE ION GENERATOR	$34.50
PG5K–PLASMA LIGHTNING GLOBE	$59.50
LHC2K–VISIBLE SIMULATED 3 COLOR LASER	$44.50
HOD1K–HOMING/TRACKING BEEPER TRANSMITTER	$49.50
LGU6K–2.5 MW HAND-HELD VISIBLE LASER GUN	$249.50
BTC3K–250,000 VOLT TABLE TOP TESLA COIL	$249.50
IOG3K–ION RAY GUN, project energy without wires	$89.50
TKE1K–TELEKINETIC ENHANCER/ELECTRIC MAN	$79.50
VW/PM7K–3 MILE AUTO TELEPHONE TRANSMITTER	$49.50

ASSEMBLED

ASSEMBLED IN OUR LABS

LIST10–INFINITY XMTR Listen in via phone lines	$199.50
IPG70–INVISIBLE PAIN FIELD BLAST WAVE GENERATOR	$74.50
PFS20–HAND CONTROLLED PLASMA FIRE SABER	$89.50
TAT30–AUTOMATIC TELEPHONE RECORDING DEVICE	$24.50
PSP40–PHASOR SONIC BLAST WAVE PISTOL	$89.50
DNE10–ALL NEW 26" VIVID COLORED NEON STICK	$79.50
LGU20–.5 TO 1MW VISIBLE RED HeNe LASER GUN	$199.50
DPL10–MUSICAL DANCING PLASMA FIRE	$99.50

EASY ORDERING PROCEDURE - TOLL FREE 1-800-221-1705
OR 24 HRS ON 1-603-673-4730
OR FAX IT TO 1-603-672-5406
VISA, MC, CHECK, MO IN US FUNDS. INCLUDE 10% SHIPPING. ORDERS $100.00 & UP ONLY ADD $10.00.
CATALOG $1.00 OR FREE WITH ORDER.

INFORMATION UNLIMITED
P.O. BOX 716, DEPT. PS8 AMHERST, NH 03031

SURVEILLANCE TELEPHONE

This is a normal functioning telephone! **EXCEPT** it has a secret built in monitor.
Only **YOU** can call and monitor all conversations, using a secret code, and never be detected! **Range Unlimited**

$175.00 — 6 month Warranty — Phone Tap Catalog $3.00
LISTEN ELECTRONICS, 603 Elgin, Muskogee, OK 74401
1-800-633-TAPS

SUBMARINE Remote Control Built from everyday items. Fun project! Blueprints $25.95 3000 Vardon, Boise, ID 83705

200 SUPPRESSED/DORMANT INVENTIONS! RARE INFORMATION DATABASE CATALOG! $2. REXCO, Box 19250, Jean NV 89019.

BUGGED? WIRETAPPED? Find out fast! Countermeasures equipment catalog $1.00. Capri, Box 589S, Bayfield, CO 81122.

51,000 CATALOGS listed. Sources For Anything! $5.95 Catalogs. Box 92452X, Atlanta, GA 30314.

BUGGED? Tapped? Hi-Tech Electronics! Surveillance! Debugging! Protection! Catalog - 1-800-232-8558.

SURVEILLANCE KITS! Telephone, Room, Combination Telephone/Room Transmitters. Catalog with **"ELECTRONIC EAVESDROPPING EQUIPMENT DESIGN"** Book Review, $1.00. Sheffield Electronics, 7223B Stony Island, Chicago, IL 60649-2806.

MICRO FM TRANSMITTER, 3 Mile range, plans $6.00 FMA, P.O. Box 4383 Bloomington, IL 61702-4383.

LASERS - Build Gunsights, Pointers, Lightshow, Nitelite, Lab. Blueprints and Instructions $9.00 Each. 3 For $20.00 Free List **NIGHTWRITERS** POB 44188 Phoenix AZ 85064

MINIATURE FM TRANSMITTERS! Tracking Transmitters! Voice Disguisers! Phone Devices! Detectors! Kits/Assembled! Catalog $2.00: XANDI ELECTRONICS, Box 25647, Tempe, AZ 85285-5647.

VCR MAINTENANCE AND REPAIR, Complete 12 Piece Kit. Easy to Use. Simple Illustrated Instructions. **FAST PROFESSIONAL RESULTS.** $9.95 PLUS $1.00 Shipping. S.E.C. SUPPLY, P.O. Box 1050, Waltham, MA 02254-1050.

SOMEBODY'S GOT YOUR KEY? REKEY LOCKS YOURSELF. Ordinary tools. Manual $6.00. Wiggins Enterprises, Box 4371-A, Deerfield Bch., FL 33442.

LASERS, from $40.00 write MWK Industries, 1269 Pomona Rd, Unit 110, Corona. CA 91720, or call 714-278-0563

MAKE Baseball Pitching Machine From Car Starter. Slinger Arm, Variable Speed, Auto Load. $20. Video Plan #10. Charles Thomas, P.O. Box 1546, Pearland, Texas 77588-1546.

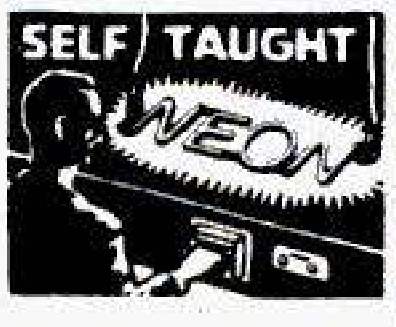
LEARN TO PAN GOLD!

LOST RIVER GOLD COMPANY GOLD PANNING KIT. Includes: 10" pan, 2 lbs. gold bearing quartz sand, instructions, Guarantee. $12.50 ea plus $3.50 S&H. Visa, M.C., Check. 424 Main, Moore Idaho 83255.

63,470 CATALOGS DIRECTORY guide. Sources for anything! $5.95: Catalogs, Box 14107AB, Jackson, MS 39236.

BUILD Ultimate necktie rack, Send $3.25 for Plans to D. Hallock, P.O. Box 3434, Shawnee, OK 74802-3434.

START YOUR OWN SHOP



Complete neon course, clearly written, with photos and diagrams. Four books, over 300 illustrations. How to earn while you learn, how to set up your shop, where to buy wholesale materials in United States. Postpaid $68.00 (U.S.). Visa okay. (Canadian $75.00). Write for details.

Peter Horsley Publications
115 Riverbirch Cres.
SE Calgary AB. Canada T2C 3M1

TIME CAPSULE: P.I.A.C.U (PORTABLE INERT ATMOSPHERE CONTAINMENT UNIT). Perfectly preserve personal/business documents in the inert atmosphere of a P.I.A.C.U. Info: $1.50, Plans: $15. **CARROTS CONCEPTS, UNLTD.,** PO BOX 510668 Salt Lake City, UT 84102.

SPEAKERS! Build your own for 50%! Customize Sound, Cabinets with Concise, Easy to Understand manual. Send $8.95: Sound-Tech, Box 13117, Wichita, KS 67213.

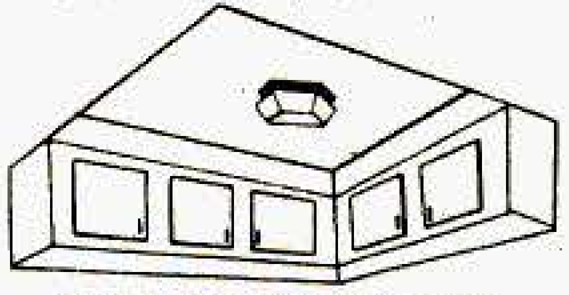
LEARN TO READ with $39.95 **VIDEO** GUARANTEE. 1071 Hansen, Merced, CA 95340.

PRACTICAL Self help fire retardant for exciting wood shake shingle roofs. Developed for U.S. government. $25.00 for complete report. C&J INFO P.O. BOX 279, Lake Hughes, CA 93532.

Build Your Own Dome Ceiling

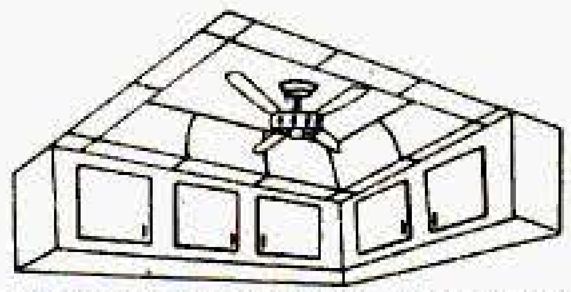
Make That Dark, Hot Kitchen...

B
E
F
O
R
E



...Bright, Cool And Beautiful
With The Exciting New
Artistic Dome Ceiling
Do-It-Yourself Manual

A
F
T
E
R

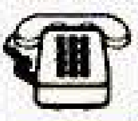


Complete Step By Step Instructions
Over 20 Illustrations
Save Hundreds on Labor And Materials
Or Start Your Own Business

Send $14.95 For Complete Plans
TO: Artistic Dome Ceilings, Inc.
11049 116th St. N.
Largo, Florida 34648
(813) 398-6620

BUG ROOM THRU PHONE

You add a circuit inside a phone. It still works the same (sends and receives calls normally) except when **ONLY YOU** call that phone and send special code - it doesn't ring - yet answers itself allowing you to listen in on room while its still on the hook! **You are not detected!** Call from anywhere at any time to listen in! Uniquely designed to work with most popular phones. Step by step instructions how to build & install. Works great. Send $9.95 to: **Laser Bounce, Inc.** 2020 Pennsylvania Ave. NW Suite 802 Washington, D.C. 20006



HOW TO SAVE DOLLARS

SEND $7.95 + P&H to: J&B MKTG, PO Box 829, New Tazewell, TN 37825.

CLOSET SHAPER EASY METHOD KIT. DESIGNED BY ARCHITECT. How to plan includes four sizes, six varieties, material lists. $12.00. Kismogyorosi, Box 627, Poolesville, MD 20837.

PORTABLE HOT TUBS

- ***Easy to build; low cost assembly***
- ***Enjoy Soothing Hot Water Massage***

Anytime • Anywhere

These TUBS currently Rent for
$200 per night!!!

Start Your Own Business! BUSINESS PLAN AVAILABLE:
Complete Plans and Parts List $9.95

BOSCA ENGINEERING
8 MARKET STREET SUITE 114 PITTSBURGH, PA 15222

CUT A/C COSTS, add evaporative cooling to your air conditioner. Licensed Engineer provides easy to follow handbook $9.95 plus $1.50 p&h. Eden Enterprises, 2738 Bartlett Blvd, Suite 186A, Memphis, TN 38134.

HARASSING CALLS. Don't Change Telephone Number. Do It Yourself Procedure. Send $10.00 M.O. R. McMullen, P.O. Box 691911, Houston, TX 77269-1911.

EDUCATION & INSTRUCTION

UNIVERSITY DEGREES WITHOUT CLASSES. BACHELOR'S, MASTER'S, DOCTORATES, ACCREDITED, INEXPENSIVE, FAST. FREE INFORMATION. DR. JOHN BEAR, PO BOX 826-PS, BENICIA, CA 94510.

HIGH SCHOOL at home, diploma awarded. Low monthly payments. No classes, information free. Phone free 1-800-228-5600, or write: American School, Dept. #347, 850 E. 58th St., Chicago, IL 60637.

PARAPSYCHOLOGY Course. Diploma. Universal Esoteric (dept. PS), Box 592191, FLA 33159.

DISCOVER SCHOLARSHIPS and **FINANCIAL AID AWARDS!** Send $1.00 p&h for information. ScholarshiPlus, P.O. Box 8374, Reno, NV 89507.

WORLD WIDE COLLEGE OF AUCTIONEERING, INC. Since 1933. Term Soon. Free Catalog COL. Gordon E. Taylor, Box 949, Dept. 3 Mason City, IA 50401. 515/423-5242.

FREE COLLEGE TAPE External Degrees Business/Public Administration LAW Graduate-Undergraduate Financial Aid. (800) 759-0005 LASALLE UNIVERSITY Mandeville, LA 70470-4000.

MAKE COLLEGE AND VOCATIONAL SCHOOL LESS STRESSING AND MORE PROFITABLE. Rush $3.50 SASE to TIPS, Box 158, Altoona, WI 54720.

BECOME A PARALEGAL. WORK WITH ATTORNEYS. HOME STUDY. FREE CATALOGUE. 800-223-4542 DEPT. LJ109.

SUPERLEARNING! Triple learning speed through music! Develop Supermemory; control stress. Free—book excerpt & catalog. Superlearning, 450-PS8, Seventh Avenue, NYC 10123.

UNIVERSITY DEGREES Without Classes! Accredited Bachelor's, Master's, Doctorates. Free Revealing Facts! Thorson-PS8, Box 470886, Tulsa, OK 74147.

BRITISH LICENTIATE in Arts or Sciences and other programmes in Management, Psychology or Philosophy. For a prospectus send $9 to: European Programme, Somerset University, Ilminster, Somerset TA19 O BQ, England.

BACHELOR'S, MASTER'S, DOCTOR'S degree programs in a wide range of subjects. Details: The Research Bureau, Poydras center-Suite 2304, 650 Poydras St. New Orleans, LA 70130.

JOKES & NOVELTIES

FREE Catalog—All-Time Favorites Plus New Surprises. **GAGS & GIFTS ANONYMOUS,** 229 Main, Hackettstown, NJ 07840.

THE ORIG. WATER BALLOOZZLE water balloon filler is yours. Fill 50 water balloons in 15 minutes. No indoor mess. Send $2 to: DUNBARTON'S, 6407 Lyndale, Richfield, MN 55432. Ship Immediately.

EMPLOYMENT INFORMATION

HOME assembly. Electronics, Automotive, crafts, typing, sewing. Apply Now! (213) 281-8111.

EASY Work! Excellent Pay! Assemble Products At Home. Call 504-641-8003 Ext. 8068.

GOVERNMENT JOBS $16,040—$59,230/yr. Now Hiring. Call (1) 805-687-6000 Ext. R-20025 for current federal list.

JOBS, Any State, Any Occupation, including Government, State, Public. Also Cruiseships, Tugs, Ships, Riverboats, Oilrigs. Women-Men. Work month- Home month. U.S.A. plus Overseas. Information $5.00. Nationwide Employment, B223 Central, Indiana 47110.

MAKE MONEY the easy way. Complete **AUCTION**-Guide shows how. Only $10.00 FINELINE Publishing, Box 2211, Sandusky, OH 44871.

OVERSEAS . . . $30,000 - $75,000 + Free Report! Employment, Box 19760-FH, Indianapolis, IN 46219.

ENERGY SAVING

WATERBED OWNERS-Save Energy. New waterbed pad makes waterbed heaters obsolete. Pad uses no electricity and produces no E.M.F.s. Pays for itself in approximately 6 months. Send $59.95 to Energy Saving Devices, P.O. Box 3606, Hayward, CA 94540.

SOLAR, GREENHOUSE, AQUACULTURE AND ENERGY SAVING CATALOG! 64 pages. Order from one expert source. Featuring Sun-Lite* for do-it-yourselfers, builders, designers. America's largest energy saving mail order house! $1.00 postpaid. Solar Components Corporation, Dept. PS. 121 Valley St., Manchester, NH 03103. PHONE 603-668-8186

ENERGY SAVING (Con't)

CO-GENERATE Electricity and Profits. Your own Micro-utility. Free Details. R&D, PO Box 221/PS, Addison IL 60101.

FINANCIAL

DEBTS? BILLS? BAD CREDIT? No problem! We'll help now. Applications accepted $500-$50,000. Not a loan company. Free app: **TCAC,** Dept. PS. 400 Century Park South #117, Birmingham, Alabama 35226 or call (205) 979-1400.

BORROW: $100 - $100,000! Fast! Confidential. Glendale Associates, P.O. Box 260279, Plano, TX 75026. 1-800-955-0081.

FINANCIAL FREEDOM! PAY OFF YOUR MORTGAGE 10 YEARS EARLY! Save $50,000 to $100,000 in mortgage interest payments! For Booklet, send $11.95 to: RBW Associates, Dept. A, 3696 Beatty Drive, Suite D, Riverside, CA 92506.

QUICK Loans, financial help! Easy Qualifying, refused elsewhere? Call 1-404-593-0244 Nationwide.

FINANCIAL WEALTH Proven success secrets revealed, guaranteed. $12.50. Doren Anderson, 1831 O'Leary Rd. Campbell River, B.C. Canada V9W 5Y8.

FOR INVENTORS

PATENT AND DEVELOP Your Invention. Registered Patent Agent and Licensed Professional Engineer. Send for **FREE PATENT INFORMATION** Every Inventor Should Have. Richard L. Miller, 12 Parkside Drive, Suite-N, Dix Hills, NY 11746. (516) 499-4343.

INVENTORS! Confused? Need Help? Call IMPAC for free information package. In U.S./Canada 1-800-225-5800.

INVENTORS: Call TLCI for free information 1-800-468-7200 24 hours/day — USA/Canada

REGISTERED PATENT ATTORNEY. D.A. Kettlestrings, 414 Hungerford Drive, Rockville, Maryland 20850. 1-800-748-6216.

DEAL DIRECT WITH
REGISTERED PATENT ATTORNEY
AND
GRADUATE ENGINEER
31 YEARS OF EXPERIENCE
U.S. & INTERNATIONAL PATENTS

Patent and develop your idea with the experience of an expert. Call or write for free confidential advice, information packet and forms for confidential disclosure and record of invention.

Overseas production, prototypes and research readily available.
INTRODUCTION TO INDUSTRY & MARKETING PLANS
Also specializing in copyrights and trademarks
Less than 1 hr from
US Patent Office
CALL TOLL FREE 1-800-442-2728
MICHAEL I. KROLL
REGISTERED PATENT ATTORNEY
US PATENT REGISTRATION 26,755
171 STILLWELL LANE, SYOSSET, NY 11791

FREE help for inventors! No charge for protection forms and information kit. Affiliated Inventors Foundation. 1-800-525-5885.

PATENT IT ECONOMICALLY! Free details. Licensed since 1958. Rainer Associates, 2008 Fondulac, Richmond, VA 23229.

INVENTORS! Can you patent and profit from your idea? Call or write for your free information package. Over a decade of service. **AMERICAN INVENTORS CORPORATION** 82 Broad Street, Dept. PS. Westfield, Massachusetts, 01086. 1-800-338-5656. In Canada call (413) 568-3753.

PROTECT YOUR IDEAS. Patents, Trademarks, Copyrights. Complete information, $5.00. Infoserve, P.O. Box 151832, Arlington, TX 76015.

LEARN how to offer your invention for sale or license. Free booklet outlines procedures, royalty rates, requirements. Kessler Sales Corporation, C-7-FI, Fremont, Ohio 43420.

UNORTHODOX is me. I sell nothing by mail. 1-314-435-9290. Evenings.

TAIWAN PATENT AND TRADEMARK REGISTRATION Low charges. Alfred & Jason, P.O. Box 82-144, Taipei, Taiwan.

WHY PATENT? Why spend two years and $4000? **INVENTOR'S REGISTRY** will prove forever when you registered the description and time of conception of your invention. License, sell, or mfg/mkt your invention confident that **INVENTOR'S REGISTRY** will be there forever to back you up! Write **INVENTOR'S REGISTRY** Rm. A, Main Post Office Box 1865, Fayetteville, AR, 72702-1865.

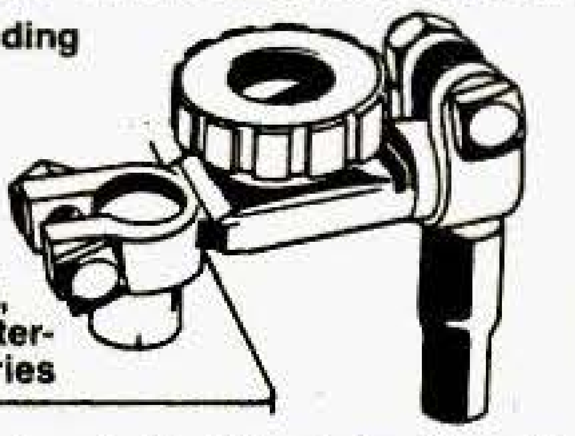
SECRETS make/sell inventions yourself inexpensively $9.95. Manual, Box 159, Rosemead, CA 91770.

COPYRIGHT YOUR - Programs, Books, Stories, Photographs, Videos: Free Information. Write EFC Publishing, Dept-PS, Box 23423, Albuquerque, NM 87192.

CLASSIC CARS

BATTERY MASTER SWITCH

Patent Pending



Can fit post, lug or side terminal batteries

Disconnects all electrical circuits with a simple turn of the knob. Attaches to battery in minutes. Heavy duty. Suitable for 12 or 24 volt batteries.

Eliminates battery drain, prevents electrical fires, provides emergency cut-off.

Remove knob to stop theft and unauthorized operation.

$12.95 each postpaid
Add $1 for side post adapter
BATHURST, INC.
Box 27-PS, Tyrone, PA 16686
814-684-2603

Quantity discounts—12 units or more.

Hemmings
Motor News
World's largest collector car marketplace
Over 750 pages each month filled with *thousands* of ads for old cars, parts, services, supplies & more.
Special Introductory Offer:
NINE GIANT ISSUES
Subscribe today ONLY $14.95 $41 in Canada
Send to:
Hemmings
Motor News
Box 100, Dept. 0817, Bennington, Vermont 05201

FOR THE HOME

CRIME DETERRENT SIX SECURITY LABELS FOR WINDOWS AND DOORS $5.00. SASE. BERGER ENTERPRISES, 4108 TREEHILLS PARKWAY, STONE MOUNTAIN, GA 30088.

GUARANTEED to pay for itself and SAVE YOU MONEY! Converts small soap pieces into FREE liquid hand soap. Patented! Send 9.95 to: Taffy Enterprises, Box 691794, Orlando, FL 32869-1794.

REMOVE ANY STAINS without buying expensive products. Send $3.95. LOGIMARC, P.O. Box 7181 Charlesbourg, Quebec G1G 5E5.

IMPROVE Evaporative A/C Operation. Detailed Plans and Manual. $7.50 P.O. Box 303, Santa Teresa, NM 88008.

CUT YOUR UTILITY BILLS in **HALF PLUS!** Saving Big on Gasoline and Auto/Truck Repairs. $12.00 Value Just $6.00. ECU, Dept PS08A, P.O. Box 789 Deer Park, N.Y. 11729.

COOL Your entire home with your window Air Conditioner Detailed illustration, $8.00. United Pac. P.O. Box 32202, Columbus, OH 43232-0202.

FOR WOOD OR BRICK **FENCE-TOPPER**™ LOW VISABILITY
SURFACE MOUNT SECURITY TAPE
NAIL OR GLUE... IT'S EASY TO INSTALL

- QUIETLY SAYS "HANDS OFF"
- REINFORCES WOOD REDUCES WARPING
- RESIDENTIAL SECURITY FOR AREAS THAT PROHIBIT BARBED OR RAZOR WIRE

CHECK OR MONEY ORDER (NO COD)
$9.95 + $3.50 S/H FOR 20 FOOT ROLL
OVER TWO ROLLS DEDUCT 10% OF TOTAL
FENCE-TOPPER SALES
7353 REMMET AVENUE
CANOGA PARK, CA
91303

MADE IN USA ALL RIGHTS RESERVED NOT FOR USE ON FENCES UNDER 5 FEET TALL

DOGS

TEACH ANY DOG IN MINUTES

Complete system, book and device. All you need to raise and train puppies, dogs of all ages. Never fails! Uses dog's keenest sense.
EASY TO USE
NOT ELECTRONIC
BEWARE OF IMITATIONS! Our Pat. #3498266 Protects You.
REHABILITATE DOGS: from Electric Shock-Shy, Gun-Shy

CORRECTS		TEACHES	
• Housesoiling	• Digging	• Come-at all times!	
• Jumping	• Gun Shy	• Sit	• Go
• Chewing	• Breaking Point	• Heel	• Self Control
• Barking	• Over Ranging	• Stay	• Guard
• Biting	• Busting Birds	• Drop	• Fetch

For: Family Dogs • Hunting Dogs • Stock Dogs • Show Dogs

ON TV with: Barbara Walters, Johnny Carson, Dick Cavett, Art Linkletter, Merv Griffin ARTICLES: SPORTS AFIELD, AMERICAN FIELD, TIME MAGAZINE, TV GUIDE, HUNTING DOG, WALL STREET JOURNAL and others worldwide.

A science engineering breakthrough! A set of unique dog-sound makers that condition dogs incredibly fast. Small. Used from the palm of the hand. Near hypnotic control, even at a distance. No leash needed. Novices become experts. This new discovery is a learning-sound **catalyst** that teaches direct to the dog's mind. Renders bodily paintraining obsolete. Safer. Kind. Yet, more powerful! Dogs simply don't fight it. Tunes dogs in, makes them **want** to please you. Unequaled loyalty-bonding. Same instruments and system (the Dr. Miller patents) dispensed by veterinarians for dog behavior. Now, thousands of satisfied users in U.S. & foreign lands.

From $25 to $175 FREE catalog
DOG-MASTER SYSTEMS
480 Wilshire, Box 1250, Agoura Hills, CA 91301
A Division of Environmental Research Labs. Copyright © 1990

GARDENING

OVERSIZED LAWNS Watering trees, shrubs. Send $3.00 to: Endicott, Box 552, Milford, IN 46542.

GREENHOUSES—Redwood/Fiberglass Kits. Hobby/Commercial sizes. FREE Brochure. GOTHIC ARCH GREENHOUSES, BOX 1564-PS MOBILE, AL. 36633. (1/800/628-4974)

COMPOST TUMBLER. Build 17 bushel composter at substantial savings over commercial models. Make compost in weeks. Detailed plans, $7.00. Planz, Box 1271, Garner, NC 27529

GOOD EATING

DAZZLE with ultimate Mexican Salsa! Secret combination produces perfect flavor. Recipe + "Indian Chile" recipe. Send $3.00 and S.A.S.E. to Steve Pennington, 1219 Logan Canon City, Colo. 81212.

INCREDIBLE Southern Barbeque: Recipes, $3.00. SASE. Box 7194, Redlands, CA 92375.

TERRIFIC TACO DIP. Perfect For Summer Parties And Picnics. $2.00, Sase. Taco, Box 821, Sidney, OH 45365.

GOVERNMENT SURPLUS

DRUG RAID SEIZURES! Buy dirt cheap. Cars, houses, boats, computers, furniture. Write: Seizures: Box 4309-YG West Covina, CA 91791.

HAIR CARE

MEN'S Hairpieces—Free Catalog! T.I.D., 2415 Main #209-PS, Stratford, CT 06497.

HEARING AIDS

HUGE SAVINGS. Eliminate dealer markup. Free Trial. Batteries wholesale. Terms Arranged. Lloyds-PSC, Rockford, IL 61104. Call 1-800-323-1212 Toll Free.

HEARING AIDS
PRICE CATALOG, FREE!

SUPER $AVINGS! Newest. Finest. All types. Buy DIRECT & save up to HALF! No salesmen. Sold by AIR MAIL on HOME TRIAL. FREE Catalog. Write:

MONEY$AVERS.
Dept. PS8D 36658 Apache Plume Dr.
Palmdale, CA 93550

HELP WANTED

EARN MONEY Reading books! $30, yr income potential. Details. (1) 8 687-6000 Ext. Y.-20025.

EASY-GUARANTEED WORK! CELLENT PAY! Assemble product home. 904-686-3634 ex-6050.

HOBBIES & COLLECTIONS

MILITARY Medals Catalogue $1 Yearly subscription $8.00. S. Vernon, 1560PS, Wildomar, CA 92395.

RADIO CONTROL - Exciting vic show you how. Airplanes 19.95 Helicop 24.95 Cars 14.95 Catalog free. Build, Race. Finest videos made. Milt Video brary, Dept PS1, 33 Lakefront Road, nam Valley, NY 10579, 800-248-MILT.

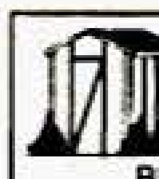
HOME CRAFTSMAN

QUARTZ CLOCK MOVEMENTS. count Prices, free Price list, TICK/TO 3035 Wilson Road, Bakersfield, CA 933

T.C. COLLECTABLES PRESENT **BONE CREATURE** DINOSAURS & WILDLIFE SERIES. PLANS/KITS. **LAR SELECTION.** 3 SIZES GREAT FOR SCHOOL, HON OFFICE, INDOOR/OUTDOOR. $4.95 & UP. **NEW**—WALL TROPHY MOUNTED BONE CREATURES! CATALOG $2.00 (CREDITED). SEND TO: JOHN F. GENERALI, DEPT 4C, 12 ROYAL PALMS DR., AUSTIN, TEXAS 78744.

NEW! BUILD AMAZING LIQUID F TON ENGINE from pipe fittings. E Plans. Free information. ABCO, Box 306 Seminary, MS 39479.

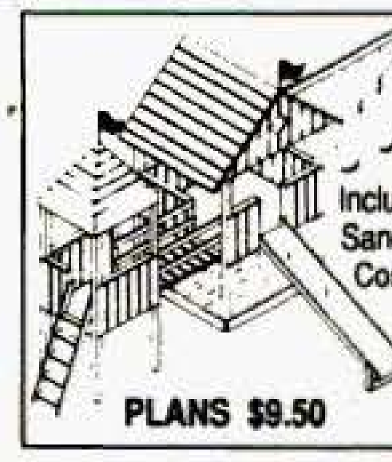
NOW! BUILD YOUR DOG A GO HOME! New! Easy Blueprints FREE U $49.99. DESIGNS, Box 22393, Savann Georgia 31403-2393.



PORT-A-BARN
BUILD THE STRONG
DURABLE & PORTABLE
BUILDING THAT HAS MANY USES

TOOL SHED • WOOD SHED • ANIMAL SHELTE
GARDEN HOUSE • POOL HOUSE • WELL HOU
PLAY HOUSE • STORAGE • SHOP

PLANS INCLUDE TWO STYLES & MANY SIZES
PORT-A-BARN, P.O. BOX 1302
HILLSBORO, OR 97123



FUN FOR KID
Big Savings For Y
Build Your Kids Their C
Backyard Playground. Pl
Include Playhouse, Tower, Bri
Sandbox, Swings & Slide. 1/3
Cost Of Commercial Playsca
SEND TO:
K & S
DESIGN PRODUCTS
P. O. BOX 864
ROUND ROCK, TX 78664

PLANS $9.50

WOODEN PICNIC TABLE - YOU C BUILD! Enjoy outdoor family dining. E plans $8.50. **WOODEN LAWN FUR TURE - 3 EASY PLANS:** recliner, be and chair. outdoor family fun! $10.50. C log of exciting (you can build) projects $1, Classic Designs, P.O. Box 3, Mt. Aukum, 95656.

BEDROOM STORAGE WITH STY Headboard is closet with bedside tab Gain dressing area and 120 cu ft stor Plans $5.00. "Headboard," P.O. Box 12 Stn B, Oshawa, ON, Canada, L1J 5Z1.

HOME BUILDING

CONSTRUCTION FINANCING Build Your Own Home. Where to get it, to use it, save thousands. Free informat Dept 10, Nowlin Consulting, 5552 Dupon Minneapolis, MN 55419.

HOVERCRAFT

HOVERCRAFT Plans, Parts, Cata $1.00. Universal Hovercraft, Box 281, C dova, IL 61242.

BARTLETT FLYING SAUCER ULTRA-LIGHT Hovercraft Featured In D umentary Film, "Force Beyond" Powered Ordinary Lawn Mower Engine. Comp Plans, Supply Sources and Photo Rev $10.00 (24 Hour Return). Send To: H Bartlett, P.O. Box 156-S, Silverdale, 98383.

HOVERCRAFT (Con't)

HOVERCRAFT Plans, 3 to 160 Hp. Information $5.00 (refundable). Sevtec, Box 846, Monroe, WA 98272

HYPNOTISM

FREE Hypnotism. Sleep Learning Publication. DLP, Box 487, Anaheim, CA 92815.

FREE Hypnotism, Self-Hypnosis, Sleep Learning Catalog! Drawer PS400, Ruidoso, NM 88345.

INVENTIONS WANTED

WE INVEST in marketable new ideas. No cost to inventor. Concept Funding (301) 876-4519.

HONG KONG factory needs several new products for their oversea buyers. Send product ideas for royalty evaluation. Can produce exclusively. Hongkong Plastic Metal Products Company, Box 69627, Kwuntong, Hongkong.

INVENTORS Your first step is important. For free advice, call **ADVANCED PATENT SERVICES,** Washington, DC, 800-458-0352.

INVENTIONS, ideas, new products! Presentation to industry and exhibition at national innovation exposition. 1-800-288-IDEA. ISC-PS, 903 Liberty, Pittsburgh, PA 15222.

INVENTORS: If you have an invention for sale or license, write for free booklet explaining how we can help you. Kessler Sales Corp., C-7-IW, Fremont, Ohio 43420.

ELECTRONIC EQUIPMENT

SURVEILLANCE - Privacy control - Debugging - Protection. (Kits - assembled) Large new catalog $5.00 Tri-Tron 2209F Lapalco, Harvey LA 70058.

LASERS: 0.5mW Rechargeable Handheld, $199.95 + $5.00 S&H. Power supplies, Tubes, 0.4-5mW. Check, Money Order, C.O.D. Free Catalog. KRL Systems, Box 9491, Stanford, CA 94309.

KITES

KITES

FREE COLOR CATALOG

Choose from over 100 kites.
Many unusual & innovative designs.
Call or write for your catalog today!
Into The Wind • (303) 449-5356
1408-P Pearl St., Boulder, CO 80302

LOANS BY MAIL

BORROW $50,000 "FAST". Any Purpose. Guaranteed. Capital, Box 561359-PS, Charlotte, NC 28256.

IMMEDIATE Loans to deserving individuals refused elsewhere. Many plans included. Try us! Associates P3, Box 9008, Baldwin, NY 11510-9008.

BORROW BY MAIL Get $500-$75,000 Quickly. Nearly everyone qualifies! Request Free application. MJS Industry, Box 531, Bronx, NY 10461-0531.

BORROW any amount! Get Visa/MasterCard! Instant reply! Sunrise, Box 42-P Bethpage, NY 11714-0042/(516) 349-1649

BORROW $500-$40,000! "Overnight" On Signature. Keep indefinitely! Action, Box 5499-Y Diamond Bar, CA 91765.

BORROW $60,000 "Overnight". Any purpose! Keep indefinitely! Free details! Write: Martin, Box 1593-SP, Safety Harbor, FL 34695.

BORROW $500—$40,000! "On Signature"! Any Purpose! 97% Eligible! Free Application: National, Box 7627-K, Long Beach, CA 90807.

BORROW $500-$200,000 quickly. Nearly everyone qualifies! Free Application. FSE, Box 10321, McLean, VA 22102.

CREDIT Repair, untold Secrets, USA Box 2168-P Van Nuys CA 91404

BORROW $100-$100,000. Quickly, on Signature/Secured Immediately! Apply Now! 1-404-879-5514.

LOOK Before You Leap! Quick Loans/Credit Card Offers **EXPLAINED** and **EXPOSED.** 1-900-988-7444. $9.95/Call.

CASH 24-48 Hours! Fast Approval! All types of loans, Car, Home, Business, Holidays. PFS, 210 Fifth Ave., Dept. 1102, NY, NY 10010.

FREE MONEY! $300,000,000 GIVEAWAY. Grants. Never repay. Details $1.00. Jakla, Box 3066-PS80, Seminole, FL 34642.

$100,000 line credit without investigation! Private Swiss bank account! Other financial benefits! Free valuable report! NACC PS-8 Box 5399, Torrance, CA 90503.

CASH GRANTS AVAILABLE from foundations! Never Repay! 401 sources/applications instructions — $3.00. Fundsearch, Box 19107-FH, Washington DC 20036.

CASH HOTLINE Loans Up To Your Yearly Income. Fast Approval With Proof Of Employment. 713-621-2204.

BORROW- $300-$100,000 by mail! Visa, Mastercard Guaranteed! TRK, Box 1058-SP, Clearwater, FL 34617.

VISA MASTERCARD! Despite Past Credit Experience! Apply Toll-Free: 1-800-888-8851, Extension 26. Issuer New Era Bank, Somerset, NJ.

ARAB BUSINESSMEN have money to buy invest. Top finders fees paid. IMEA. 0890/PS1. Box 3574. Newport Beach, CA 92663. (714) 722-9260.

MAGIC TRICKS, PUZZLES, ETC.

PROFESSIONAL MAGIC! Huge Catalog, over 1,000 Tricks and Books. $4.50. Hank Lee's Magic Factory, Dept. PS8, 125 Lincoln Street, Boston, MA 02111.

MAILING LISTS

NEW NAMES DAILY! IMMEDIATE SHIPMENT! Guaranteed Opportunity Seekers. Adhesive labels. 200/$8; 500/$11; 1,000/$18; 2,000/$29; 5,000/$59 **QUALITY LISTS,** Box 6060-CW, Miller Place, NY 11764. VISA/MC/COD. 800-356-6392.

NEW ACTIVE NAMES!!

MIXED STATES! IMMEDIATE SHIPMENT! Adhesive Labels — Hot Line Opportunity Seekers, 200/$10.00; 500/$15.00 1000/$25.00. Others. **ADVON** Drawer B6, Shelley, ID 83274, Visa/MC/AmEx. **1-800-992-3866.**

FIRST ORDER "TRIPLED FREE"! Opportunity seekers! Computerized, adhesive labels. 200/$5; 500/$9; 1,000/$15; 2,000/$24; 5,000/$49; 10,000/$92. **LIST-MASTERS,** Box 425-WK, Mt. Sinai, NY 11766. Visa/MC/COD call 800-356-8664.

MISCELLANEOUS

MOSQUITOES A PROBLEM! Ouch, now there is something you can do about mosquitoes. Used in Europe and finally introduced to you in America. Environmentally safe, no chemicals, new application. Don't get stung, act now for plans to safer fun outdoor activity. Rush $9.95 to Mosquitoes A, Box 15250, Duluth, MN 55815.

BUSINESS CARDS $25.95. FREE INFORMATION: CARDINAL, 10159 MONROE, TAYLOR, MI 48180-3613.

HANDBOOK On Shaping hedges, shrubs by eye and otherwise. $6.50. Good Earth, P.O. Box 96, Seymour, Conn 06483.

WELDING, SOLDERING

COMPLETE Portable Aluminum Welding Kit, MAB Corporation, Box 14, Dix, NE 69133, $194.95. (800) 535-2850.

ELECTRONICS, STEREO, HI-FI

BUILD SUBWOOFER - Speaker Enclosures. $5, Tex. Res. add 38¢ Tax, DataTec, PO Box 396, Pleasanton, TX 78064.

MONEYMAKING OPPORTUNITIES

BUMPERSTICKER PRINTER. Cheap, simple, portable. Free details. Bumper, P.O. Box 22791 (LLD), Tampa, FL 33622

MAKE Rubber Stamps. Highly Profitable. Free details. STAMPER, P.O. Box 22809 (LLD). Tampa, FL 33622

ILLUSTRATED Instructions for 50 Fun, Useful, Sellable Projects incorporating Plastic Soda Bottles. Send $5.00 to Pop-Jects, P.O. Box 6349, Texarkana, TX 75505.

EASY Work! Excellent Pay! Assemble Products At Home. CALL 504-641-8003 EXT. 6517

GET PAID FOR FUN

GET Paid for fun. For Information and Tips to earn extra money on things you enjoy doing, send $12.50 to: AB Publishing, PO Box 630 East Windsor, CT 06088.

BIRD HOUSES MADE EASY! Ideal for Flea Markets, Gifts, Extra Money, or Fund Raisers, Unique Booklet with detailed drawings and material lists. 3 Designs for $6.00, 6 for $10.00 DMM Enterprises, P.O. Box 9306, VA. Beach, VA 23450

DOUBLE YOUR INCOME! LOOK YOUNGER! $22.95 Video and 13 Premier products. Booth Distributors Suite 131, 5738 Redwood, SLC, UT 84123.

$10,000.00 MONTHLY TAKING PHOTOGRAPHS AT HOME! NO EXPERIENCE. (213) 549-0997 (90 SECOND RECORDED INFORMATION).

REPAIR YOUR CREDIT RATING. Plus Fill Your Bank Account With Cash. Free Details. 800-874-7093.

$400, PLUS DAILY, AT HOME. No experience. All Rights and Materials. COMPLETE PROGRAM $29.95 (U.S.) Starts you Today! For additional information send $2.00 (Redeemable on Purchase) to ECU, Dept PS08C, P.O. Box 789, Deer Park, NY 11729.

EXCELLENT Extra Income! Easy Home Assembly Work. 24 Hour Recording. (619)966-6083 Dept. 105.

10,000 MONTHLY potential free details. Anderson Publishing, 37 Pidgeon Hill Dr., Suite 102, Sterling, VA 22170.

OF INTEREST TO ALL

GOLD CREDIT CARD GUARANTEED APPROVAL. NO BANK DEPOSIT NECESSARY. CATALOG SHOPPING USA GOLD CARD 1-800-888-7774.

COLLEGE DEGREES, High School Diplomas. Authentic looking. Free Catalog. Dept. PS-148, National Certificate, 210 5th Avenue, New York, 10010 (718) 768-6803 - (24 HOURS).

MOBILE HOMES—RVS! Screws rusting? Cover them—Samples $1.00. COVER-UPS, P.O. Box 133, Genoa, OH 43430.

RECYCLE Motor Oil and Make Money! Send $1.00/SASE—McGhee, Dept. 17, 634 Roper, Houston, TX 77034.

PROTECT YOUR PRIVACY, Identity, Top Secret, P.O. Box 3286, Laguna Hills, CA 92654.

OLD GOLD, JEWELRY WANTED

TAKE NO CHANCES, Deal with oldest, most reliable firm in old gold business. Established 1934. We buy Gold, Silver, Platinum, Diamonds. Highest Cash. Free information. Rose Industries, 29-Y East Madison, Chicago 60602.

HIGHEST CASH for Gold, Jewelry, Gold Teeth, Rings, Diamonds, Watches, Silver, Platinum. Mail Articles Today. Free gift with Information. Chicago Gold & Precious Metals, 10 S. Wabash, Dept. 1257, Chicago, 60603.

HUNTING & FISHING INFO

"WOODIE BASS STICKS"- Unique wooden bass lure. 'Many Master Angler Awards.' 4/10.00. Wolverine Tackle, P.O. Box 567, Keego Harbor, MI 48320.

MUSICAL INSTRUMENTS

INTERNATIONAL VIOLIN COMPANY tonewood, tools, varnishes, parts, accessories, strings, cases, instruments, bows. Violin, guitar kits. Catalog $1.00. Dept. PS 4026 W. Belvedere Ave., Baltimore, MD 21215.

PLANS, BLUEPRINTS

COMPOST Complete Building Plans Send $19.95: CMB Services, P.O. Box 935 Streamwood IL 60107.

PRACTICAL, efficient **"DESTRUCTOR"** Reduces almost anything to ash Plans $7.95 - BCC Inc. PO Box 489, Cairo NY 12413.

MURDER cleaning your gas barbecue Convert to self cleaning in 1½ hours (WORKS GREAT!) Send $7.50 for plans to Clean Bee R.D. 3 Box 312 Goshen, NY 10924.

PLASTICS

CASTOLITE Liquid Plastics. Crysta clear, colors. For casting, embedding, coating, fiberglassing, repairing and reproducing with our Mold Making Supplies. Catalog $2.00. **CASTOLITE,** Dept. 90K/PS, Box 391, Woodstock, IL 60098.

LEARN How to Mold and Make your own Products from **PLASTIC** - Free Information. CPM, P.O. Box 195, Oakville, IA 52646.

REAL ESTATE

BUILD YOUR DREAM IN COLORADO Build your cabin from your own trees Create a pond from Crystal Clear Water Harness Solar Energy from over 300 days o unclouded sky. 35 Acres from $22,900. Low Down Easy Terms. Free Brochure Call Today 1-800-383-0583. Patten Land of Colorado Corp.

MONTANA LAND BARGAINS: 20 Acre mountain parcels starting at $12,900. Call NOW for **FREE** information. **1-800-252-LAND.** Yellowstone Basin Properties.

GOVERNMENT HOMES from $1 (U repair). Delinquent tax property. Repossessions. Call 805-687-6000 Ext. GH-20025 for current repo list.

FLORIDA'S WEST COAST. Lots $4,000 up. Map Brochure. Englewood Realty 1-800-842-1962.

CALIFORNIA. Acreage. Lots. $50 down $50 monthly. 4602 Ethel Ave., Sherman Oaks, CA 91423.

RADIO, TELEVISION

SECRET Scanner Frequencies: Federal Police, etc. Free Catalog! CRB, Box 56PS Commack, NY 11725.

ROBOTS

ROBOTS! Personal and Industrial fully Assembled and Kits Robot Arms, PC Interfaces, Sensors $30.00 to $80,000 catalog $5.00 Refundable with order. HTO, P.O. Box 3084, RSF, CA 92067.

SCIENCE & CHEMISTRY

225 PAGES! 1988 Glassware, chemicals, equipment, books, experiments, DINOSAURS and charts! Most comprehensive catalog offered by anyone in this column. Established 1970. $3.00(US) **REFUNDABLE** Analytical Scientific, 11049 Bandera San Antonio, TX 78250. (512) 684-7373 VISA.

CHEMICALS AND LAB EQUIPMENT Chemicals, small or large quantities, for your convenience. Glassware, Scales, Microscopes available. Send $5.00 for catalogue. Chem Lab, 1060-C Ortega Way Placentia, CA 92670.

"EXPERIMENTERS" LABORATORY CHEMICALS - GLASSWARE. Catalogue $1.50. established 1953 Hagenow Laboratories. 1302 Washington, Manitowoc, Wisconsin 54220.

HYDROGEN Balloons made easily with home supplies $3.00. Jacobson Associates, 104 Bailey Drive, North Branford, CT 06471.

COLD FUSION: Everything known, so far. Send only $8.85, DOBBS, Box 657, Richmond, VA 23205.

SONG WRITERS

POEMS—SONGS WANTED. Free Publishing/Promotions. Broadway Music, Box 7438-PS, Sarasota, FL 33578.

POPULAR SCIENCE–THE BENEFIT

Each month Popular Science classified ads reach out to over 4.4 million readers. If you are looking to reach involved, inquisitive prospects, call me to advertise your product or service.

Dorothy Ellis
1-800-445-2714, (212) 779-5163

SPECIAL SERVICES

INFORMATION On Anything. Ferguson Research Specialists. 60-15 Woodside Avenue, Woodside, NY 11377.

TRANSFER old home movies to VHS tape. 4¢ per foot! Free details. Send SASE. VIDEOS, PO Box 617, Middletown, Ohio 45042

STAMP COLLECTING

DISCOUNT Stamps, Request Countries, Free List. IVA, Box 197-B, Hanford, CA 93232.

50 DIFFERENT Old U.S. Between 1861 and 1939. $1.00. Rousch, Box 3734, Mansfield, OH 44907.

UNITED NATIONS 3 Mint Sets, 25¢. Cornetta, POB 1509-P, Lake Placid, Florida 33852.

PENNY Stamp Approvals. Regardless Catalog. C. Kloster, 4164 52nd St. San Diego, CA 92105.

TELEPHONES & ACCESSORIES

HILARIOUS CASSETTE OF ANSWERING MACHINE MESSAGES (over 20 in all). Only $4.95 + $2.00 p/h to: ZAL PRODUCTIONS, 1671 East 16th St., Suite 214, Brooklyn NY 11229. (N.Y. Residents add 8 ¼% sales tax).

TOBACCO, PIPES, CIGARS

SUNLITER® Solar Cigarette Lighter Windproof Waterproof, Lifetime Guarantee $5.00. SPT, 15490 S.W. 82 Ln #112, Miami, FL. 33193.

TOOLS & MACHINERY

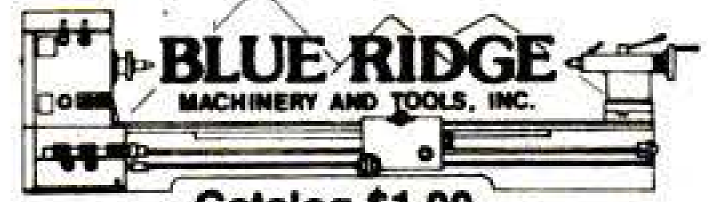
BOLTS, SCREWS, TOOLS, WHOLESALE, DIRECT. Guaranteed. Catalog $1.00 (refundable). Camelot, Dept. 33, Box 65, Bristol, Wisconsin 53104.

4" METAL Cutting Lathe $114.25., Taig, 15048 Proctor, Industry, CA 91746.

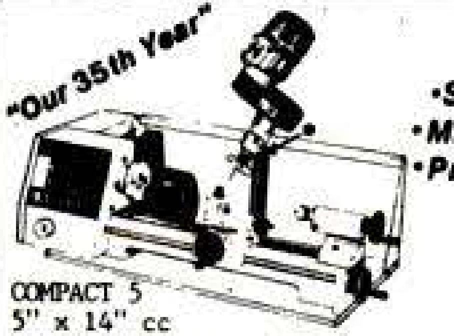
SMALL FOUNDRY Furnace Supplies. Free Literature. Pyramid Products, Dept. M, 3736 South 7th Avenue, Phoenix, AZ 85041.

"SHARPENERS REPORT" Monthly Newsletter. Tips—Sources—Used Equipment. FREE Brochure. SKOG Company, Dept. PS8, PO 22559, Minneapolis, MN 55422.

LATHES — MILLING MACHINES
MACHINE SHOP SUPPLIES — TOOLS



Catalog $1.00
P.O. BOX 536-PS, HURRICANE, WV 25526 • (304) 562-3538
Unimat • Compact • Maximat • Myford • Sherline • Atlas • Jet
Toll Free Number For Orders



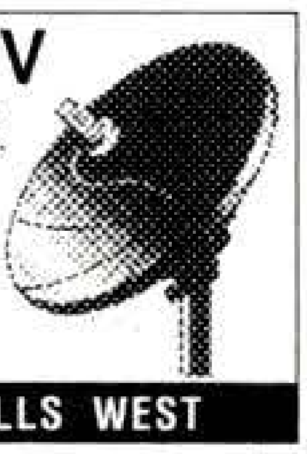
LATHES
•STARTING AT $350
•Mills •Metals •Books
•Precision Instruments
Catalog $2.00
(1000's of items)
513-322-8562
CAMPBELL TOOLS COMPANY
2100P Selma Road, Springfield, Ohio 45505

SATELLITE TV

Satellite-TV
FREE Catalog
Save 30%-60%
Systems, upgrades, IRDs, movers, Feeds, LNBs, 3' to 24' dishes and more...
Names Like –
Monterey, Uniden, Drake
HTS, Orbitron, etc.
800-334-6455
218-739-5231 MN & INT.
SKYVISION INC.®
2026 COLLEGE WAY
FERGUS FALLS, MN 56537

INSTALL OR UPDATE YOURSELF!

SATELLITE TV
Call for FREE 32 Page Catalog.
All MajorBrands. Lowest Prices.
WEST
1-800-222-9064
1741 Cedardale Rd.
Mount Vernon, WA • 98273



NOBODY UNDERSELLS WEST

SATELLITE TELEVISION DESCRAMBLERS Complete Detailed Plans For Home Construction By Anyone. $5.00. Jansen Electronics, P.O. Box 25161, Seattle, WA 98125

VIDEOCIPHER Technical Manuals Including Software. Catalog - $3.00. **TELECODE,** P.O. BOX 6426-PS, Yuma, AZ 85366-6426.

TREASURE FINDERS, METAL DETECTORS

FIND Old Coins, Jewelry, Gold Nuggets, New Patented Revolutionary Device. Free Catalog. Gardiner Electronics, 3131L N 35th Ave., Suite K, Phoenix, AZ 85017.

BURIED TREASURE

Locate from a LONG DISTANCE
with Ultra Sensitive *DIRECTIONAL* Locator
SEND FOR
FREE INFORMATIVE BROCHURE
RESEARCH PRODUCTS
BOX 270270-H TAMPA, FLORIDA 33688

VIDEO EQUIPMENT

RENTAL MOVIE STABILIZER. Connect between VCRs or to monitor. $69.95. 1-800-367-7909.

FREE! SPACE & SCIENCE VIDEOS CATALOG. Write: Space Flight Production, 38 Brawley Ave., Toronto Ontario Canada M8Z4Z4.

WIRELESS CABLE RECEIVERS
1.9 TO 2.7 GHz

30 CH Parabolic Dish System-$173.90
30 CH Rod Antenna System-$193.90
30 CH Crystal Controlled System-$294.95

SUN MICROWAVE INT'L. INC.
P.O. BOX #34522
PHOENIX, AZ. 85067
(602) 230-0640

Send $1.00 for catalog on these and other fine video products

VISA/MC/AMEX QUANTITY DISCOUNTS LIFETIME WARRANTY
MEMBER OF THE BETTER BUSINESS BUREAU

RUBBER STAMPS

MAKE Rubber Stamps. Highly Profitable. Free details. STAMPER, P.O. Box 22809 (LLX), Tampa, FL 33622

Size: Approx. 5/8" x 2"
A Great Gift!
HANDY
YOUR NAME & ADDRESS (UP TO 4 LINES) A REAL TIME SAVER!

Order "CUSTOM MADE"
RUBBER STAMPS
UP TO 4 LINES only $2.95 ea.
(Max.30 letters per line)
INK PADS only $1.95 ea.
Specify Color Black, Blue, Red, Green
Add 25¢ per item for postage
SATISFACTION GUARANTEED
FAST SERVICE - Your Order Shipped in 5 days!
QUALITY Stamp Mfg. Box 35514-S, Tulsa, OK 7415

WINEMAKING

WINEMAKERS-BEERMAKERS Fr Illustrated Catalog - Fast Service - Larg Selection - Visa/Mastercard - (816) 254-024 **KRAUS,** Box 7850-N, Independence, Mi souri 64053.

BEERMAKERS—Winemakers Fre Catalog. Fast Service, Free Recipes. Cella S, Box 33525, Seattle, WA 98133. 80 342-1871.

WINEMAKER—BEERMAKER: Fre Illustrated catalog of supplies. Semplex P.O. Box 11476H, Minneapolis, MN 5541

FREE CATALOG! GREAT PRICES FAST SERVICES! SEBASTIA BREWERS, 1762-S SUNRISE LAN SEBASTIAN, FL 32958, (40 589-6563.

THE COUNTRY WINEMAKER AN BREWER. 161 antique recipes from gene ations past. $7.25 postpaid. Teaparty Pu lisher, Box A232, Kingston, MA 02364.

WATER PURIFICATION

DRINK PUREST WATER! Home Di tributors, Discount Prices! 800-874-902 **WATERWISE,** Box 45981, Center Hil 33514-0459.

SOLAR POWERED WATER PUR FIER For Swimming Pools, Eliminat Chlorine. Free Information. MTI. P.O. B 1651, St. Louis, MO 63011. (314) 383-002

STEEL BUILDINGS

FACTORY CLEARANCE UP TO 40 OFF. SAVE To $5000 on STEEL BUIL INGS, 25 × 30, 30 × 40, 40 × 60, others. Fa tory Direct 1-800-548-6871.

VIDEOS

WITHOUT GLASSES View Your Vi eos, Photos in 3-D Instructions $14.9 **NEWVISION,** 380 St. Denis, Ottawa, Can da K1L 5H7.

Classified Advertising

POPULAR SCIENCE CLASSIFIED OPPORTUNITY MART

Order Form

$10.50 PER WORD
10 word minimum
BOLD FACE CAPS
add $1.00 a word

WORD COUNT: Each word or initial in name and address must be counted as a word: John E. Jones, 345 East Main St., counts as SEVEN words. P.O. Box 3 counts as THREE words. City, standard 2-letter state abbreviation and zip code together count as TWO words.

DEADLINE FOR ADS: See head of classified section.

TERMS: Payment with order or charge your VISA, MasterCard, American Express or Diners Club account.

TO: Classified Advertising Dept. POPULAR SCIENCE, 2 Park Ave., New York, NY 10016.

☐ Remittance of $________ is enclosed to cover ________ insertion(s) in the ________ issue(s).

☐ CHARGE to: ________________ Exp. Date ________

Heading my ad should be under: ________________

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16
17	18	19	20

YOUR NAME ________________ (PLEASE PRINT) PHONE ________

FIRM ________________

ADDRESS ________________

CITY ________ STATE ________ ZIP ________

DATE: ________ YOUR SIGNATURE ________________

(PLEASE PRINT OR TYPE COPY • FOR ADDITIONAL WORDS ATTACH SEPARATE SHEET)

PS 8/90

ADVERTISEMENT

Product Information

Booklets, catalogs, and folders listed below provide reliable information, illustrations, and specifications to help you in planning the purchase of a variety of products or services offered by these dependable companies. The convenient order form will save you time and postage. **Orders will not be processed unless accompanied by the $1 handling fee. For your safety, please do not send cash.**

801 Car Care Scotchguard Protective Gel is a car-care product from 3M. A brochure explains how Scotchguard protects, cleans, and enhances inside and outside surfaces. Free

802 On-line Computer Communications CompuServe's informative brochure shows you how to use and communicate through the world's largest and most comprehensive computer information service: hardware and software support, electronic mail, personal investment services, and more. Free

803 Water Treatment "The Water In Your Life" from EcoWater is an eight-page booklet about home water problems, how they occur, and how they can be corrected to provide a higher quality of life. Free

804 Advanced Heat Pump The "All the Comforts of Home... and Then Some" brochure from Edison Electric describes the development of the EPRI/Carrier advanced heat pump, whose operating efficiencies are 30 to 40 percent over conventional heat pumps. Also discussed are the operation and advantages of variable speed compressors. Free

805 Hobbyist Catalog Edmund Scientific's 80-page catalog contains over 1,200 products, including telescopes, magnets, weather instruments, high-tech toys, fiber optics, and ideas for science-fair projects. Free

806 Oil Additive A brochure from Fluoramics describes Tufoil, a spectacular low-friction and low-wear oil additive. Tufoil makes changing your oil a patented engine treatment. Enjoy fast starts, smooth operations, better acceleration, and longer engine life. Free

807 Solariums Literature from Four Seasons Solar Products includes: Series 200 and 300 Patio Room brochures, Mod-U-Glaze brochure, Four Seasons Quiet Aire Roof Ventilation System brochure, Window and Patio Door catalog, and Steel and Royal Classic catalogs. $10

808 The Dome: Beautiful Efficiency A 125-page catalog from Geodesic Dome provides information for building and finishing energy-efficient geodesic homes. It includes color pictures and more than 80 popular floor plans from 1,000 to 5,000 square feet. $8

809 Luxury Dream Homes A book from Home Planners contains over 150 of the best luxury home plans from seven of the top designers and architects in the United States. The plans range in size from 3,000 to 8,200 square feet and feature all styles of homes. Blueprints are also available. $12.95

810 Paint and Varnish Removal Klean Strip's two free booklets, "Protect Your Home Like A Pro" and "Guide To Paint and Varnish Removal," offer important information for homeowners, do-it-yourselfers, and weekend handymen. Free

811 Pool Cleaning The Kreepy Krauly Automatic Pool Cleaning System keeps your pool clean by vacuuming it every day. It comes with an exclusive three-year warranty, 15 years on its only moving operational part. Free

812 Outdoor Clothing L. L. Bean's fall catalog features active and casual wear, fall sports equipment, and furnishings for home and camp. L. L. Bean pays for the postage and offers toll-free telephone services. Free

813 Cedar Homes Spectacular custom cedar homes are featured in the 240-page Lindal Cedar Homes Planbook. Draw fresh inspiration from over 750 color photographs of new homes. You can even draw your own custom plan with the tools we provide. $15

814 Clean and Protect The "Touch of Glass" brochure from Liquid Glass Enterprises shows the various uses for its products on cars, boats, and airplanes, and contains examples of why it is a "total appearance" system for your prized possessions. $1

815 M1 Tank Platoon The definitive simulation of armored land combat is now available from MicroProse Software with U.S. tank platoons that have four M1s. Four soldiers operate each: That's four tanks, 16 men, and you control the whole shooting match. All the fun of a four-tank platoon in one great game. $1

816 North Carolina Vacation The state of North Carolina offers a travel package containing facts for planning where to go, where to stay, and what to do on a North Carolina vacation. Free

817 Insulation and Savings The "Homeowners Guide to Insulation and Savings" from Owens-Corning is a guide to home energy savings and comfort. The booklet explains where and how to insulate in an existing home, in a remodeling project, and in new home construction. Free

818 Septic-System Help Unfortunately, your septic system can back up. But Rid-X helps you avoid septic-system failure. The company's booklet tells how your septic system works and how you can help it keep working. Free

819 Gas Savers U.S. Auto-Tech's full-color catalog features innovative products designed to save gasoline, increase engine and car life, and maintain high-performance motoring. Featured are the famous Slick 50 products. $1

820 Travel Computer The Interstate Travel Computer from Whistler is an electronic device that lists more than 30,000 roadside businesses, services, and tourist sites along major U.S. interstate highways. Through a series of detailed questions, the product determines where you are located and provides both the distance and directions to gasoline, food, lodging, and service facilities along your route. Free booklet

FILL IN COUPON AND MAIL TODAY

POPULAR SCIENCE P.O. Box 1695, Riverton, N.J. 08077-7295

Note: POPULAR SCIENCE New Jersey address is for Product information only.

POPULAR SCIENCE AUGUST 1990

Please send the items checked below. I am enclosing $1 handling charge (any number of items **per coupon**) plus amount required for priced items. **Orders will not be processed unless accompanied by the $1 handling fee. Do not send cash.**

☐ 801
☐ 802
☐ 803
☐ 804
☐ 805
☐ 806
☐ 807 $10
☐ 808 $8
☐ 809 $12.95
☐ 810
☐ 811
☐ 812
☐ 813 $15
☐ 814 $1
☐ 815 $1
☐ 816
☐ 817
☐ 818
☐ 819 $1
☐ 820

I AM ENCLOSING

$__________for priced items
$ 1.00 for handling
$__________TOTAL REMITTANCE

Name (please print)____________________

Address__________ **City & State**__________ **Zip**__________

Please send check or money order made out to POPULAR SCIENCE.
No stamps or foreign currency. Allow approximately six weeks' delivery.

THIS COUPON EXPIRES OCTOBER 31, 1990

Looking Back...

Sampling a century of POPULAR SCIENCE

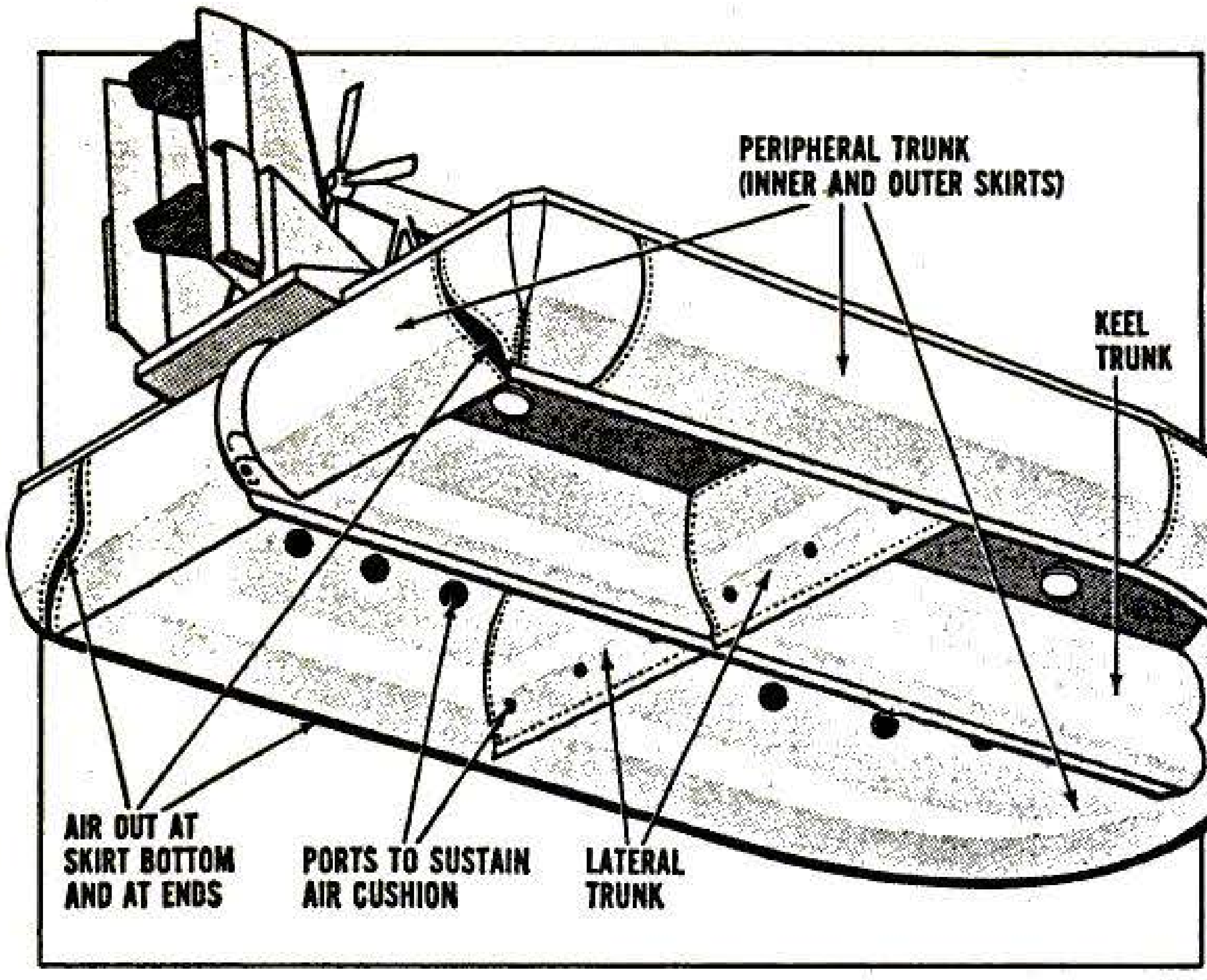
25 YEARS AGO

AUGUST 1965

"I've just had an exhilarating ride across land and water on a four-foot cushion of compressed air in an amazingly comfortable machine that's a blend of bus, boat, balloon, and helicopter.

"The vehicle was a pert 15-passenger Hovercraft, one of a pair that have become the first ground-effects machines (GEMs) to enter commercial passenger service in the United States. The British-built GEMs have recently begun ferrying travelers across the bay between the Oakland and San Francisco international airports.

"The Hovercraft looked like the upper half of a cabin cruiser snuggled in a nest of tarpaulin. The nest was the inflatable rubber tubing through which air is forced beneath the vehicle to make it airborne. The vehicle did a gentle "push-up" and began drifting across a concrete strip at Oakland airport. There was a surface wind from the northwest, but the Hovercraft turned its nose into the wind and sidled along the runway until we got up enough speed to give its rudders bite."


PERIPHERAL TRUNK (INNER AND OUTER SKIRTS)
KEEL TRUNK
AIR OUT AT SKIRT BOTTOM AND AT ENDS
PORTS TO SUSTAIN AIR CUSHION
LATERAL TRUNK

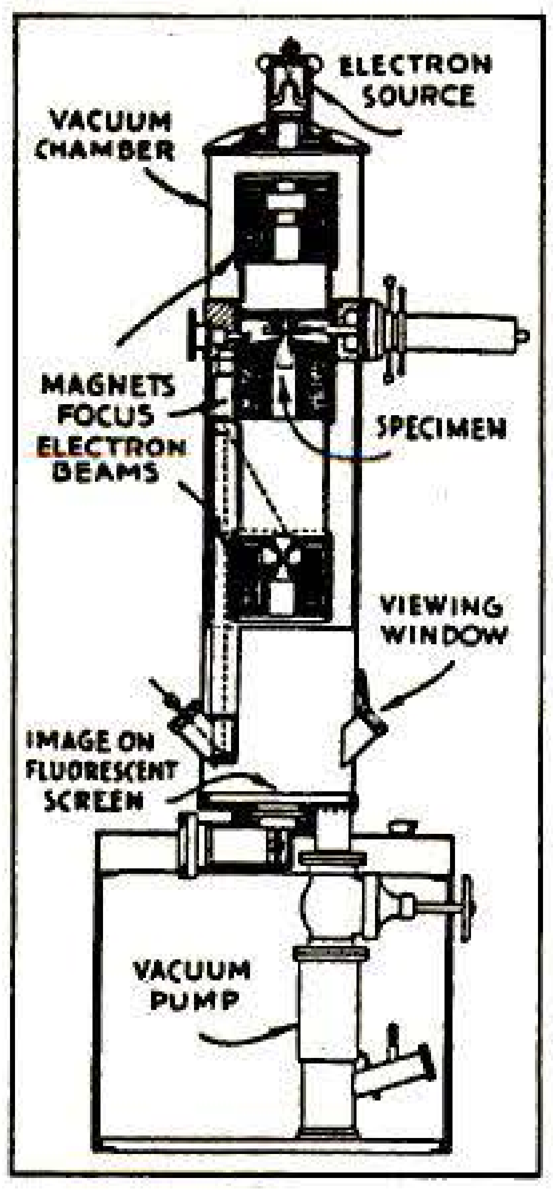
50 YEARS AGO

AUGUST 1940

"Electrons—those invisible electrified particles that whirl like the stars of our solar system in every atom of matter—are performing hundreds of amazing new tasks in science and industry. By modern electrical wizardry, they are being made to do everything from opening garage doors and sorting dried beans to aiming the big guns on our first-line battleships.

"Just a few days ago, the Camden, N.J., laboratory of the Radio Corp. of America announced an electronic microscope capable of bringing into view minute specimens more than 40 times smaller than the smallest visible under any conventional instrument. With it, science may soon view objects so small that they've never before been seen by the human eye.

"Employing streams of electrons instead of beams of light, and electrically energized magnets instead of lenses, the $18,000 electronic microscope resembles a giant metal vacuum tube. Streaming down from the upper end of its 10-foot cylindrical barrel like rays of light, beams of electrons produced by an electrically heated filament are focused on the specimen to be magnified. Then, passing through electromagnets, which deflect them just as lenses bend rays of light, the electrons strike a fluorescent screen at the bottom of the microscope. This bombardment causes the screen to glow like the viewing screen of a television receiver and produces in visible light an enlarged image of the tiny specimen under study. By regulating the strength of the magnets and the flow of electrons, the operator is able to control the magnification so that objects may be either photographed or studied visually."



100 YEARS AGO

AUGUST 1890

"The region was a particularly difficult one in which to conduct sanitary relief. Along a narrow mountain valley for 28 miles was scattered some 28 towns and villages, forming Johnstown. Of these, 20 were devastated by the flood, which left almost every village isolated from the others, all bridges and roads being destroyed, as also all horses and vehicles, thus rendering communication extremely difficult or impossible.

" 'No pen has yet described the condition that existed the day after the waters of the South Fork Lake had swept the valley. The homes that were not swept away were left in the most unsanitary condition imaginable. The flood in many localities reached a height of 30 feet. This water contained every kind of filth, and whatever this water touched it contaminated. As a result, every house in the flooded district was filled to the second floor, in most cases with offensive matter. There was not a place where the flood touched that man could lay his head with safety.'

"The state work at Kernville, a ward of Johnstown, is an index for all the district. 'With the concentration of 2,500 people in 380 homes, it is gratifying to know that during the board's operations no infectious diseases developed that could be attributed to bad sanitary conditions.' "

This account of sanitary conditions facing Johnstown after the great flood on May 31, 1889, was written by G. G. Groff, M.D., LL.D., president of the Pennsylvania State Board of Health.

Quality is Job 1.℠

Profile in quality #17: Precision.

You're looking at the most automated suspension and drive train assembly system in North America. Ford Motor Company helped design and develop this new technology which now allows the engine and body to come together in controlled alignment. Continuous improvement in assembling today's vehicles is vital in today's competitive car market. If your goal is to build the highest quality cars and trucks in the world—you don't do it any other way.

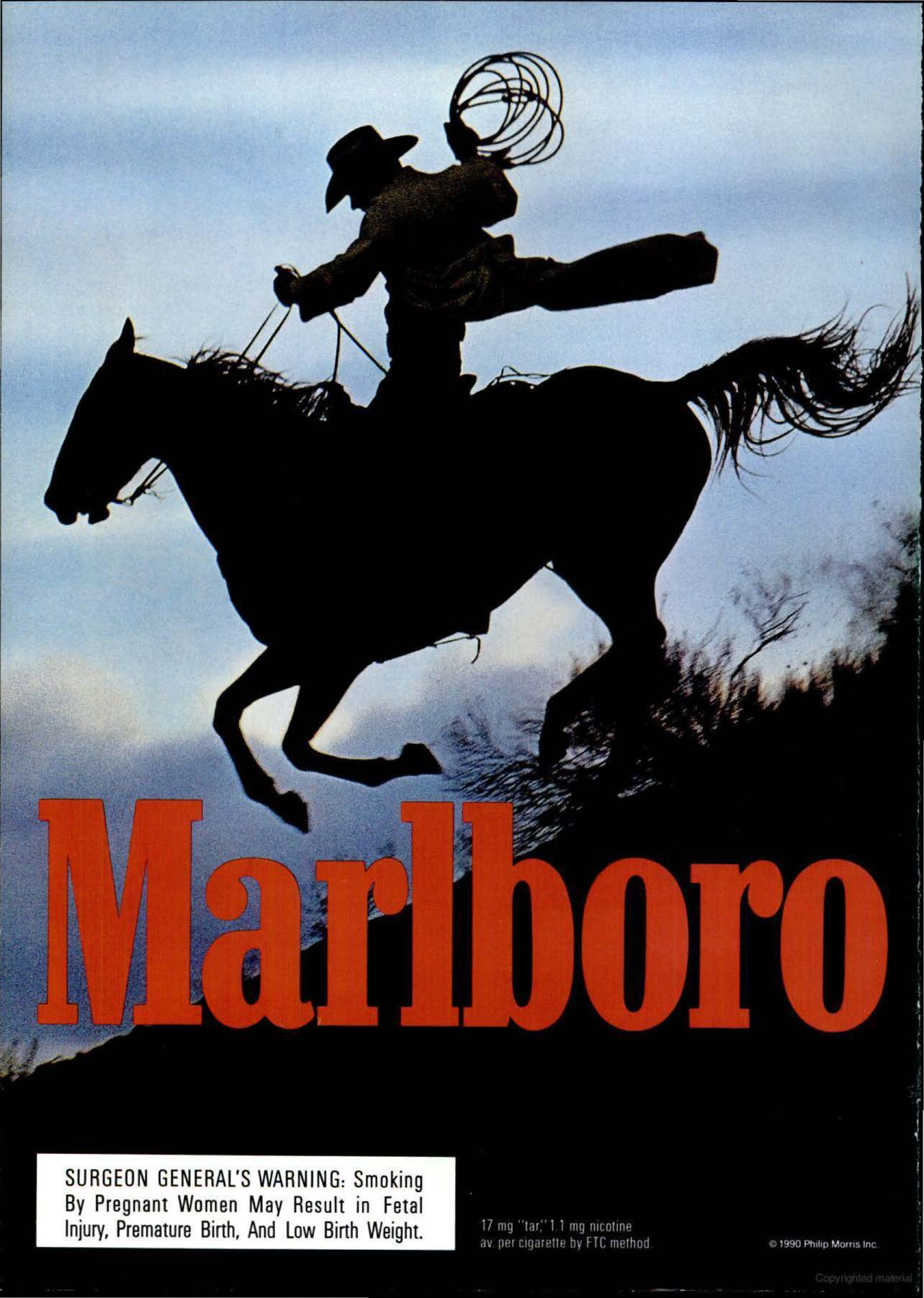
**Ford, Mercury, Lincoln, Ford Trucks.
Our goal is to build the highest quality cars and trucks in the world.℠**

Ford

FORD MOTOR COMPANY

Buckle up—together we can save lives.

Copyrighted material



SURGEON GENERAL'S WARNING: Smoking By Pregnant Women May Result in Fetal Injury, Premature Birth, And Low Birth Weight.

17 mg "tar," 1.1 mg nicotine
av. per cigarette by FTC method.

© 1990 Philip Morris Inc.

Copyrighted material